



CIVIL ENGINEERING STUDIES
Illinois Center for Transportation Series No. 13-013
UILU-ENG-2013-2008
ISSN: 0197-9191

PEDESTRIAN/BICYCLIST WARNING DEVICES AND SIGNS AT HIGHWAY- RAIL AND PATHWAY-RAIL GRADE CROSSINGS

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Research Report FHWA-ICT-13-013

A report of the findings of
ICT-R27-96
**Pedestrian/Bicyclist Warning Devices and Signs at
Highway-Rail and Pathway-Rail Grade Crossings**

Illinois Center for Transportation

April 2013

Technical Report Documentation Page

| | | | | | |
|--|--|--|--|---|-----------|
| 1. Report No. FHWA-ICT-13-013 | | 2. Government Accession No. | | 3. Recipient's Catalog No. | |
| 4. Title and Subtitle Pedestrian/Bicyclist Warning Devices and Signs at Highway-Rail and Pathway-Rail Grade Crossings | | | | 5. Report Date April 2013 | |
| | | | | 6. Performing Organization Code | |
| | | | | 8. Performing Organization Report No. ICT-13-013 UILU-ENG-2013-2008 | |
| 7. Author(s) Paul Metaxatos and P.S. Sriraj | | | | 10. Work Unit (TRAIS) | |
| 9. Performing Organization Name and Address Urban Transportation Center University of Illinois at Chicago 412 South Peoria Street, Suite 340 Chicago, Illinois 60607 | | | | 11. Contract or Grant No. R27-96 | |
| | | | | 13. Type of Report and Period Covered | |
| | | | | 14. Sponsoring Agency Code | |
| 12. Sponsoring Agency Name and Address Illinois Department of Transportation Bureau of Materials and Physical Research 126 E. Ash Street Springfield, IL 62704 | | | | | |
| 15. Supplementary Notes | | | | | |
| 16. Abstract Federal reporting shows a relatively constant number of pedestrian and bicycle fatalities at highway-rail and pathway-rail grade crossings over the past 10 years. This is in contrast to a marked decrease in train-vehicle collisions at highway-rail crossings. Although engineering solutions and education and enforcements initiatives have been proposed and implemented, little is known about their effectiveness to mitigate such incidents. This study reports on findings from the literature, discussions with professionals in the public and private sectors involved in safety at rail grade crossings, and pedestrian/non-motorized user behavior and attitudes toward safety at such crossings. The study highlights the multitude of factors related to pedestrian safety in this context and provides an informed discussion for stakeholders to advance safety initiatives. | | | | | |
| 17. Key Words Pedestrian and bicyclist safety, pedestrian warning devices and signs at rail grade crossings | | | 18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161. | | |
| 19. Security Classif. (of this report) Unclassified | | 20. Security Classif. (of this page) Unclassified | | 21. No. of Pages 77 plus appendices | 22. Price |

ACKNOWLEDGMENT, DISCLAIMER, MANUFACTURERS' NAMES

This publication is based on the results of ICT-R27-96, Pedestrian/Bicyclist Warning Devices and Signs at Highway-Rail and Pathway-Rail Grade Crossings. ICT-R27-96 was conducted in cooperation with the Illinois Center for Transportation; the Illinois Department of Transportation, Division of Highways; and the U.S. Department of Transportation, Federal Highway Administration.

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EXECUTIVE SUMMARY

Federal reporting shows a relatively constant number of pedestrian and bicycle fatalities at highway-rail and pathway-rail grade crossings over the past 10 years. This is in contrast to a marked decrease in train–vehicle collisions at highway-rail crossings. There is limited research on the subject of how to reduce the number of collisions between trains and pedestrians and bicyclists at highway-rail and pathway-rail grade crossings. The objective of this research is to determine best practices for providing effective warnings to non-motorized users of highway-rail and pathway-rail grade crossings that (1) inform the user of the presence of a crossing, and (2) inform the user to take appropriate action to prevent a collision. The study was divided into five components:

1. Literature review
2. Survey of state agencies and industry professionals
3. Identification of ten hot spots to be used for survey locations
4. Survey of non-motorized users—analysis of stated pedestrian behavior
5. Video surveillance of non-motorized users—analysis of observed pedestrian behavior

The study highlights the multitude of factors related to pedestrian safety and provides an informed discussion for stakeholders to advance safety initiatives. The focus of this research is on individuals who use legally authorized highway-rail crossings with pedestrian access, or legally authorized pathway-rail crossings. Such highway-rail and pathway-rail crossings can be identified because they have a U.S. DOT inventory number assigned to the location (e.g., 372133T). Individuals crossing railroad tracks at locations other than legally designated locations are trespassing on private property. While trespassing is a major public safety issue, it is not the focus of this research.

An extensive review of the pertinent published literature concerning pedestrian safety related to highway-rail and pathway-rail grade crossings found a distinct lack of any standards to analyze/quantify pedestrian risk and design effective treatments to reduce the risk to pedestrians from being struck by a train. The word “pedestrian” as used in this report refers to all types of non-motorized users. The primary findings from the literature review include the following:

1. A wide variety of MUTCD-compliant signs and devices are used to warn pedestrians of the presence of a crossing, as well as the approach of a train. However, a large number of non-compliant MUTCD signs and devices are also used.
2. The warning signs and devices include pavement markings, detectable warnings (e.g., audible tones, verbal messages, and/or vibrating surfaces), channelization devices (e.g., different types of fencing, swing gates, zigzag/Z-gates, corrals), audible/visual warnings (e.g., low-rise flashing pedestrian signals, multi-use path flashing light signals), automatic pedestrian gates (e.g., short gate arms), and “second train coming” electronic warning signs.
3. The effectiveness of any particular sign or device in reducing the risk of a collision between a pedestrian and a train is unknown.
4. A number of criteria are used to select warning devices for deployment at pedestrian–rail grade crossings, including pedestrian collision experience at the crossing, frequency of inclement weather, pedestrian volumes and peak flows, train speeds, number of trains, railroad traffic patterns, surrounding land uses, sight distance for pedestrians approaching the crossing, skew angle of the crossing relative to the railroad tracks,

existence of multiple tracks, vicinity to a commuter station, and installation/maintenance costs.

5. Few existing methodologies allow for assessing trade-offs among those factors during the selection process, and the potential of newer approaches is not well understood.
6. In particular, there is no commonly accepted method to quantify the risk to pedestrians of being struck by a train at either a highway-rail crossing with pedestrian access or at a dedicated stand-alone pathway-rail crossing.

The second phase of the study consisted of telephone interviews with representatives of 25 state agencies with jurisdiction over grade crossing safety. Additional interviews were conducted with representatives of national or federal agencies with responsibility for grade crossing safety, as well as individuals with extensive experience in the consulting engineering community. From these interviews, a few general themes emerged to increase the awareness of stakeholders and help advance pedestrian safety at rail grade crossings:

1. Safety upgrades at dedicated pedestrian crossings are not prioritized as highly as those at highway-rail grade crossings unless the two types of crossings are adjacent to each other (e.g., adjacent sidewalks on one or both sides of a highway-rail crossing extending to the other side of the tracks).
2. The vast majority of funding available for safety improvements is usually planned for rail-highway crossings; very rarely are these funds scheduled exclusively for dedicated pedestrian grade crossings.
3. States with substantial passenger, commuter, and freight rail operations are leading the effort to develop guidelines and engineering standards for safety improvements; in particular, California seems to have taken the lead.
4. Cost estimates and/or actual costs of the warning systems already installed are not readily available.
5. Criteria for the selection of warning devices for deployment at pedestrian-railway grade crossings are used on a case-by-case basis, likely because of a lack of available methods to assess criteria trade-offs.
6. Strong local advocacy is the most important factor (other than adequate funding) behind effective education, outreach, and enforcement safety campaigns at pedestrian-rail grade crossings.
7. Education and enforcement campaigns must be sustained over time and place and use a variety of techniques to engage the user community. Campaigns for commuter and light-rail grade crossing safety can be relatively more effective with the active participation of the transit agency and a captive local audience exposed to the frequency of transit operations.
8. There is no consistent approach for managing risk at pedestrian-rail grade crossings that could ensure (1) the uniformity and continuity of data collection programs and administration of related databases on all such crossings; (2) the analysis of risks at such crossings; (3) the prioritization of crossing upgrades; (4) the introduction of suitable risk controls; and (5) the assessment of cost effectiveness of such measures.
9. Non-motorized users at grade crossings within quiet zones might not receive safety warning comparable to those given to motorists. As a result, distracted non-motorists, especially when traveling in groups, may not be sufficiently alerted to an incoming train, especially when a second train is coming from the opposite direction.
10. It is likely that pedestrian safety at rail grade crossings will improve in the longer term by the increasing consistency in standards for warning devices and treatments among organizations responsible for this task.

11. The requirement for extra warning time for pedestrians and motorists at grade crossings of high-speed rail operations is emerging as an additional issue for safety upgrades at such crossings.

The third phase of the study consisted of identifying ten locations at which to conduct a survey of users, as well as video observation of users. The survey of users and video observation of users permitted a relative comparison of the effectiveness of existing warning signs and devices, as well as extensive analysis of user perception and behavior pertaining to pedestrian safety at grade crossings.

The objective of the user survey was to obtain at least 30 valid surveys from each of the ten locations. A total of 312 usable surveys were obtained. Findings from the user survey merit attention because they may have implications about the design and placement of signs and warning systems at pedestrian-rail grade crossings:

1. Certain activities, such as talking on a cell phone, pushing a stroller, or listening to music on earphones, may interfere with environmental awareness while traveling across a grade crossing. In addition, such awareness appears to diminish with age.
2. Active warning signs at grade crossings are noticed more frequently than passive signs, independent of gender or frequency crossing use. Moreover, younger users are more likely to pay attention to active signs, while older users notice passive signs more frequently.
3. The mean age of the respondents was 43 and the median 48. Combined with the fact that the respondents were generally better educated than the region as a whole, education and enforcement programs should be designed to take this into account.
4. Being a regular user at pedestrian-rail grade crossings appears to help with awareness of signs and warning devices. Moreover, regular users appear to be more safety conscious compared with irregular users. More than 90% of respondents indicated they never cross tracks at locations other than the legally designated crossing. Irregular users were more likely to cross illegally.
5. Overall, female respondents in all age groups appear to be more safety conscious than male respondents when using a crossing. In addition, young males (under 21 years old) appear to be the only group in this sample more likely to cross the tracks against activated signals/warning devices.
6. The majority of respondents (59%) have seen others crossing the tracks against activated warning devices. Trespassing by crossing the tracks at locations other than a pedestrian crossing is still a habit of a small minority of users (10%) that merits attention.
7. Safety improvements at pedestrian grade crossings should always consider the special needs of people with disabilities, who constitute a sizable minority of users.
8. In the small number of instances when a respondent indicated having trouble navigating a crossing, he or she said that a poor-quality pedestrian surface was responsible.
9. More intensified educational and enforcement campaigns are necessary to convince all pedestrian users that (1) it is illegal to cross against activated signals/devices and (2) crossing the tracks at locations other than a pedestrian crossing constitutes trespassing.
10. The propensity of pedestrians to be in violation of activated devices and signs while crossing the tracks decreases when crossings are equipped with pedestrian gates.
11. The number of respondents who noticed the "second train" warning sign at Villa Park was 48%. This electronic warning sign received the second highest level of awareness of all warning signs and devices present among survey respondents at the single location where it is installed.
12. Pedestrian gates had the highest level of awareness of all warning signs and devices present among survey respondents.

13. Half of all respondents did not suggest anything to improve safety, but of the half that did, adding pedestrian gates was the most popular response, followed by increased enforcement and grade separation.

The final phase was collection of video data from the ten locations. A total of 7,624 observations were recorded. The video data analysis was undertaken to evaluate (1) the effect of crossing characteristics on pedestrian behavior, (2) the compliance of pedestrians with existing control equipment, and (3) the variations in pedestrian volumes and their impact on crossing behavior. The following findings complement other observations made in other parts of this study:

1. Pedestrians who took the most risk by ignoring lowered gates found themselves having to cross the tracks in a hurry compared with pedestrians who adhere to the rules.
2. In certain situations with larger platoons crossing the tracks at the same time (e.g., getting on/off commuter/light rail, school start/end times), the clearance interval was longer, which has potential implications for extending the warning times by providing more warning in advance.
3. Larger groups of pedestrians are more likely to commit a violation against activated devices or signs compared with lone pedestrians and groups of two pedestrians.
4. Pedestrian gates have an even stronger effect on deterring actual (compared with stated) pedestrian behavior of crossing the tracks illegally, even after controlling for variations between crossings and train direction.

In closing, this project pulled together into one comprehensive report a number of findings concerning the relative effectiveness of pedestrian warning signs and devices at highway-rail crossings with pedestrian access. Extensive analysis of stated and observed pedestrian behavior yielded valuable insights into potential improvements that can be implemented to improve the safety of pedestrians at highway-rail and pathway-rail grade crossings.

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CHAPTER 1 LITERATURE REVIEW

1.1 INTRODUCTION

The amount of domestic and international research on train-related accidents is enormous, although the number of such studies related to non-motorist safety at rail grade crossings is more limited. Lobb (2006) distinguished the literature on train-related accidents in three broad categories: (1) research on major railway disasters, such as derailments, train–train collisions, and buffer over-runs; (2) research on road–rail crossing accidents in which a motor vehicle collides with a train at a legal crossing point; and (3) research on train–pedestrian accidents. All these accidents constitute a very small proportion of those occurring in transportation compared with road accidents in developed countries such as the United States (Miller et al. 1994) and Great Britain (Evans 2003). Nevertheless, their impact is high in both human and financial terms because, although not all result in serious injury, many cause death or high morbidity such as amputation of limbs (Moore et al. 1991; Smith 1995; Blazar et al. 1997).

In the United States, despite a 69% reduction in road–rail crossing accidents from 1978 to 1994, hundreds of fatalities still occur every year, resulting in economic losses amounting to more than US\$1 billion in medical costs, insurance payments, legal fees, and damages to railroad property (USDOT/FHWA 1994). Goldberg et al. (1998) calculated that the annual direct cost to society in the United States exceeded \$300 million annually. Indirect costs—medical costs, insurance payments, legal fees, and damages to property—must push such estimates into billions of dollars, not to mention the human tragedy that each accident represents.

The number of non-motorist fatalities at rail grade crossings remains relatively unchanged in contrast to the declining number of fatalities resulting from train–vehicle collisions at highway–rail grade crossings. Horton et al. (2009) reported that between 1994 and 2007, incidents at highway–rail grade crossings declined 44%. However, between 2003 and 2007, the number of pedestrian incidents remained unchanged. Factors contributing to these trends are identified and discussed in the following sections of this chapter. Particular attention is given to the effectiveness of warning devices and signs.

Non-motorized incidents (pedestrians, bicycles, and wheelchairs) at rail grade crossings are not to be confused with trespassers — individuals who trespass on railroad rights-of-way private property at locations other than authorized grade crossings, including overhead and underground crossings.

1.2 HUMAN FACTORS AFFECTING NON-MOTORIST SAFETY

In this section, we examine the demographic characteristics as well as attitudes and behaviors of non-motorists who are typically involved in incidents at rail grade crossings. In Illinois, Savage (2010) identified four types of pedestrians at rail facilities and recommended that safety measures be targeted for each group: (1) passengers crossing between/to platforms, (2) pedestrians at grade crossings who are not passengers, (3) trespassers away from grade crossings, and (4) non-vehicular suicides. The study found that males were overrepresented in all four categories. Despite media attention, youth are not often involved in rail crossing fatalities. In addition, Illinois trespassers tend to be older than the national average.

A retrospective computer search of the records of the Jefferson County, Alabama, Coroner/Medical Examiner Office covering the 15-year period from 1981 to 1995 revealed 86 cases in which either a train caused death or in which a body was found dead by the tracks (Davis et al. 1997). The average age of the decedents was 39 years, and men accounted for 88% of the deaths. The manners of death were as follows: 3 natural, 64 accidents, 7 suicides, 6 homicides, and 6 undetermined. Six decedents were found dead by the tracks, but death was not caused by a train. Six decedents were railroad employees who died on the job. In 47 cases, the decedents were trespassing on railroad property. Five trespassers were riding the rails, and

42 were pedestrians struck by a train. All together, 45% of the decedents were intoxicated. Intoxication was greatest by far in individuals witnessed to have been lying on the tracks before being hit by a train.

A 7-year review of 23 consecutive train accident victims in the United States showed that 20 (87%) were male, with an average age of 30.6 years (Shapiro et al. 1994). Sixteen (70%) were intoxicated at the time of the accident. There were 8 traumatic amputations that occurred in the 11 (48%) patients involved as pedestrians. Two of these were railroad workers, and 9 were trespassers. Fourteen (61%) accidents occurred between the hours of 2300 and 0700. Three (14%) patients died.

These findings seem to agree with the international experience. A 5-year study of all non-collision and derailment fatalities in Australia by Nixon et al. (1985) determined that the individuals most likely to sustain an injury or be killed were male. The authors determined that 36% of fatalities were related to individuals crossing the tracks, that 30% of adults injured or killed were under the influence of alcohol, and that 13% of fatalities were suicides. In addition, the study determined that youth fatalities fell into one of two categories: (1) toddlers wandering onto the tracks out of the supervision of their parents and (3) teenage boys struck as cyclists or pedestrians. Moreover, in South Africa, Lerer and Matzopoulos (1997) found that the majority of railway-related fatalities were pedestrians crossing the tracks and that the majority of victims were males between the ages of 25 and 44. The authors found that alcohol was present in 35% of the fatal cases.

In a study regarding pedestrian behavior, Khattak and Luo (2010) examined specific types of violations at gated highway-rail grade crossings. The authors found that children younger than 8 years old were involved in 25% of violations. The study also found no significant difference in the occurrence of violations between bicyclists and pedestrians. Younger children were more likely to cross in the absence of older children or adults. However, for individuals older than 8 years old, the presence of more people increased the likelihood of a violation.

Huntley-Fenner (2008) discussed psychological differences between pedestrians and motorists that may contribute to pedestrian–train collisions. The study indicated that while vehicle–rail collisions have decreased, pedestrian collisions have risen. In addition, pedestrians near passenger rail facilities may interpret auditory warnings as an indication that the train is approaching and that they should hurry to get in boarding position. The study also indicated that specific perceptual factors must be taken into account when considering active warning devices at rail crossings.

A study by the Illinois Commerce Commission (2005) looked at 39 incidents involving pedestrians (including bicyclists and other non-motorized users) struck by trains in northeastern Illinois between 2000 and 2004 and found that

- Sixty-six percent (22 of 33) of the pedestrian–train collisions investigated appeared to have been caused by the pedestrian disregarding the warning devices that indicated a train was approaching; many of these crossings were equipped with pedestrian gates.
- Twenty-one percent (8 of 39) of the pedestrian–train collisions occurred at Metra station crosswalks that comprised only 10% of all grade crossings in northeastern Illinois. This is most likely due to the high volume of pedestrians exposed to train traffic at the Metra station crosswalks.
- Sixty-four percent (25 of 39) of train–pedestrian collisions resulted in a fatal injury to the pedestrian. This represents one of the highest severity rates of all transportation-related incidents.
- Pedestrian warning devices, including pedestrian gates, are commonly ignored and easy to circumvent.

- Pedestrian–train collisions are evenly split between male and females and that the age cohort of 40 to 49 experienced more incidents compared with other age groups.

1.3 SAFETY AT PEDESTRIAN CROSSINGS

1.3.1 Warning Devices

A compilation of existing pedestrian safety devices at grade crossings documents active and passive devices both in and not included in the *Manual on Uniform Traffic Control Devices* (MUTCD) (USDOT/FRA 2008). Examples of devices illustrated include audible/visual devices, such as low-rise flashing pedestrian signals and multi-use path flashing light signals; highly reflective passive warning signs; short gate arms; channelizing devices, such as fencing, swing gates, and zigzag (also known as Z-gates); and “second train coming” electronic warning signs.

The report recommended that “the selection of a traffic control device for use where pedestrians are intended to cross railroad tracks at grade should be the result of an engineering study whose simplicity or complexity will be determined by conditions at the crossing in question” (USDOT/FRA 2008, p. 26). According to the report, various factors that should be examined during device selection include the following:

- collision experience, if any, at the crossing, as it involves pedestrians;
- pedestrian volumes and peak flows, if any;
- train speeds, numbers of trains, and railroad traffic patterns, if any;
- sight distance that is available to pedestrians approaching the crossing; and
- skew angle, if any, of the crossing relative to the railroad tracks.

A study evaluating the effects of the installation of a train-activated signal intended to warn pedestrians when two or more trains are approaching a highway-rail intersection was conducted in Los Angeles by Khawani (2001). The study examined the best methods for selecting a site, design of the signal, and education efforts related to the installation of the signal. The study defined risky pedestrian behavior by the time elapsed between the pedestrian entering the tracks and the arrival/departure of a train. The study found that the installation of the signal reduced the incidence of risky pedestrian behavior.

A “second train coming” warning sign demonstration project was conducted by the Los Angeles County Metropolitan Transportation Authority (TRB 2001). In that case, the pedestrian sidewalk crossed two light-rail transit (LRT) tracks and two freight rail tracks. The study found that the warning sign was effective in reducing risky behavior as measured by an overall 14% reduction in the number of pedestrians crossing the LRT tracks less than 15 seconds in front of an approaching LRT train. Additionally, the number of pedestrians crossing the LRT tracks 6 seconds or less before an LRT train entered the crossing was reduced by about 32%. Finally, the number of pedestrians crossing the tracks 4 seconds or less in front of an approaching LRT train was reduced by 73%.

The Long Island Railroad second-train changeable message sign system became operational in November 2002, with the primary intent of improving pedestrian awareness and safety (Ogden 2007). Ogden reported that the system is activated only during a second-train event. As a result, crossing users can misinterpret non-activation of the system during single-train arrival events to mean that it is safe to circumvent the deployed gates. Furthermore, the only maintenance cost associated with the system is periodic testing, which is currently performed monthly in addition to the scheduled crossing maintenance.

The Federal Railroad Administration released a report on the North Carolina Department of Transportation’s “Sealed Corridor” assessment (U.S. DOT/FRA 2009 and 2004a). It discussed the impacts of treating 44 private crossings with improved warning devices or closure within a period of time between 1990 and 2008. The study used two approaches for benefits of

lives saved: (1) analysis of collisions and (2) predictions based on reduction of risk at the crossings. The fatal collision analysis estimated that 1.5 lives had been saved through December 2008 because of the improvements, while the risk factor analysis estimated the improvements would save approximately 0.39 people per year. Although the study did not distinguish between motorist and non-motorist user benefits, it assessed a Norfolk Southern Railway onboard video that captures, at four frames per second, real-time digital video and audio of track conditions as well as unusual events, such as incidents and trespasser activity, through the use of a camera and microphone installed on the locomotive. In addition, NCDOT Rail Division and Norfolk Southern have initiated a joint research project with FRA to develop and validate a predictive trespasser model using the data collected on both the Sealed Corridor and Norfolk Southern's system as a whole. In addition to model calibration, the data will be used to determine the effectiveness of potential preventive measures designed to minimize pedestrian–train interactions.

Little (2009) examined the benefits of “another train coming” (ATC) warnings at grade crossings. The study focused on locations in Australia, Canada, the United States, and Japan. Little found that a small portion of accidents related to the arrival of a second train, and all accidents involved pedestrians or cyclists. The study recommended that when warnings are put into place, they must be clear in order to reduce risk. The study also found that human factors that can increase risk include failing to check or detect warnings and not standing in a safe position. Thirty-two warning options were identified and reviewed, which included static signs, dynamic signs, and audible warnings. Workshops were conducted to narrow the 32 options down to 5: a static sign with miniature warning light, an audible warning with voice and “warble,” an active visual warning, a visual warning as soon as the second train “strikes-in,” and a “red standing man” (or hand) to enhance warning. The study also determined that the costs of design, installation, testing, and commissioning were higher than the cost of the warning equipment.

1.3.2 Warning Signs, Fencing, and Landscaping

The FRA Secretary's Action Plan outlined nine strategies to increase safety at highway-rail crossings for all users, including pedestrians. Specific strategies included increased education and enforcement. The report recommended well-designed fencing, pedestrian channelization, and video monitoring of well-known trespassing locations to reduce trespasser conflict and cited a successful relationship working with Canadian officials in this regard (USDOT/FRA 2004b).

In an effort to create guidelines for pedestrian treatments at light-rail facilities, Siques (2001) identified four factors to consider when installing pedestrian treatments and provided recommendations for each. The factors to be considered were (1) pedestrian awareness of the crossing, (2) pedestrian path across the trackway, (3) pedestrian awareness and ability to see the approaching light-rail vehicle, and (4) pedestrian understanding of the potential hazards at grade crossings. The study suggested that pedestrian awareness of the crossing can be enhanced by passive signs and tactile warnings and recommended that the pedestrian pathway be subject to channelization and positive control devices. In addition, the author recommended that a pedestrian's ability to see an oncoming vehicle can be improved through sight lines and active warning devices, and that pedestrian understanding of the hazards of crossing can be increased through public outreach and education.

Siques (2002) also examined the effects of certain treatments on risky pedestrian behavior at light-rail facilities. The study evaluated five different types of treatments: (1) pedestrian automatic gates, (2) a prototype active pedestrian warning device, (3) a prototype active “look both ways” sign, (4) barrier channelization at a skewed crossing, and (5) a “stop here” pavement marking. The study found that each treatment type was successful in reducing risky pedestrian behavior. Pedestrian automatic gates were found to be the most effective at

reducing risky pedestrian behavior. However, the study also concluded that some treatments may increase risky pedestrian behavior. Pedestrians were less likely to look both ways in the presence of a gate in the down position.

Irwin (2003) discussed safety criteria for light-rail pedestrian crossings in regard to TriMet (the public transportation service provider) in the Portland, Oregon, metropolitan area. TriMet began its study by conducting an independent review to identify enhancements to reduce risky behavior. This review resulted in prototype installation of safety treatments at various crossings. The safety treatments included signage, swing gates, detectable warnings, channeling pedestrian traffic, audio-visual warnings, and automatic pedestrian gates. The trial found that the crossing improvements increased safety awareness.

In a study of pedestrian and vehicular safety related to light-rail service, Korve et al. (2001) performed a before and after study on the effectiveness of presignal warnings on motorist behavior in corridors with pedestrian crossings. The study developed guidelines and recommended the implementation of presignal warnings. The study also discussed risky pedestrian behavior at light-rail crossings and recommended pedestrian-scale warning devices such as automatic gates, pavement markings, education, and enforcement. Finally, the study discussed best practices of agencies in the United States for reducing risky behavior of both motorists and pedestrians at light-rail grade crossings.

A study in DuPage County, Illinois, examined the pedestrian crossing environment at selected grade crossings (TranSystems Corporation 2005). The environment ranged from no dedicated pedestrian crossings to pedestrian crossings on both sides of the roadway. The study recommended a number of basic warning measures for all the crossings to increase pedestrian or bicyclist awareness of their approach to a rail crossing. At crossings with multiple tracks, higher train speed and a high level of train traffic amplify the risk to pedestrians. This is especially true in locations where these factors are coupled with nearby commuter stations. In these instances, the study recommended that train-activated LED flashing train-warning signs be provided at eye level. In particular, three warnings should be displayed at crossings with multiple tracks: (1) train approaching, (2) second train approaching, and (3) sign warning of fines associated with non-compliance with warning devices.

The same study revealed that (1) there is no written set of standards that apply directly to pedestrian crossings of the railroad; (2) the use of pedestrian gates is not generally encouraged because they are perceived to be ineffective and not cost effective. The perception is that unless gates are coupled with a method of channelizing the pedestrian traffic, the gates are too easy to walk around or under. However, Metra, the commuter rail operator in northeastern Illinois, did not seem to object to the use of pedestrian gates and will assume responsibility for performing all future maintenance of the enhanced crossing protection if the requesting party pays the installation costs (Metra Ordinance No. 97-15).

1.3.3 Accessible Non-Motorist Signals

Accessible pedestrian signals (APS) are devices that communicate information about pedestrian timing in non-visual formats such as audible tones, verbal messages, and/or vibrating surfaces (MUTCD, Section 4A.01) (USDOT/FHWA 2009a). APS can provide information to pedestrians about the existence and location of the pushbutton; the onset of the walk interval; the direction of the crosswalk and location of the destination curb; the clearance interval; intersection geometry through maps, diagrams, or speech; intersection street names in Braille, raised print, or speech; and intersection signalization (Barlow et al. 2003; Harkey et al. 2007). Description of such features is given in the published guidelines by the U.S. Architectural and Transportation Barriers Compliance Board (2005). Korve Engineering (2007) found only limited research testing APS under field conditions and no additional research other than Blasch (1999) comparing the effectiveness of different APS in normal traffic conditions.

In the United Kingdom, Delmonte and Tong (2011) conducted a comprehensive analysis to identify solutions for improving safety and accessibility at level crossings for disabled pedestrians. They recommended the following 12 key solutions to address key deficits in accessibility at grade crossings. These solutions are mapped in the accompanying diagram, which is also taken from the same report (Figure 1).

- S01: Improved audible warnings using dynamic volume adjustment to ensure continuous audibility above background noise. This assists pedestrians who have residual hearing and helps all pedestrians make better use of the audible warnings (especially those with sight loss).
- S16: LED wig-wags provided whenever there is scope to upgrade from incandescent bulbs to improve signal visibility for all users.
- S20: Wider use of the flashing red man pedestrian signal to help all pedestrians identify the crossing and assist specific groups with knowing when it is not safe to cross. Particularly useful when line of sight from an approaching pathway to the wig-wags is poor.
- S28: Corduroy tactile paving surfaces before transverse pathway lines on all approaches to all grade crossings (where few are provided with pathways) to help people with sight loss to identify grade crossings.
- S29a: Tactile longitudinal white guidelines over the grade crossing pathway to assist pedestrians with sight loss to navigate a safe path over the crossing.
- S47: Marked surface to warn pedestrians where it is not safe to stand because of the risk of being struck by a lowering barrier. This would benefit deaf pedestrians, who cannot hear the audible warning, as well as other groups who may be unaware of the hazard.
- S53: Non-reflective materials for the crossing surface to prevent reflected glare from the crossing, which can disorient and temporarily “blind” pedestrians with sight loss, as well as others.
- S57: Improved consistency for transverse pathway lines by ensuring that they are used at all crossings with a pathway and are applied in a consistent form (i.e., a solid white line). This reduces confusion for all pedestrians.
- S60: Level, consistent, and rubberized crossing surfaces for pedestrians that are distinctly different from the surfaces used for approaching pathways. This helps pedestrians with sight loss detect the crossing surface and also benefits pedestrians with other disabilities by further defining the crossing and ensuring it is uniform and physically undemanding to cross.
- S61: Level and consistent surfaces for approaching pathways (where provided) that are distinctly different from the crossing surface itself to help pedestrians with sight loss reliably detect level crossings. Benefits also exist for all pedestrians with disabilities because the crossing itself becomes a clearer feature on the highway.
- S66: Consistent, color-contrasting fencing for barrier-lifting mechanisms and grade crossing areas. This assists pedestrians with sight loss and other groups identify and navigate the crossing without colliding with hazardous obstructions.
- S67: Color contrast for wig-wag posts. This helps pedestrians with sight loss and other groups identify and navigate crossings without colliding into wig-wag posts on the pathways.

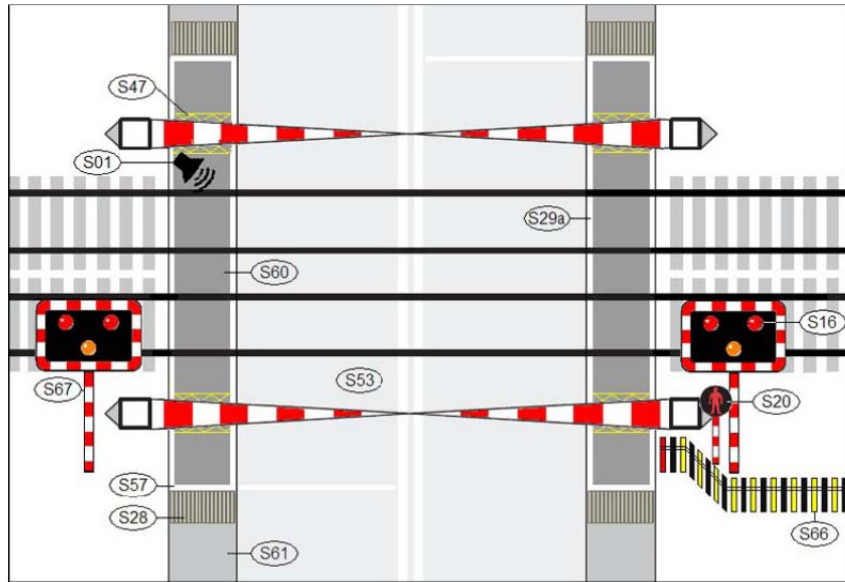


Figure 1. Solutions for key deficits in accessibility at grade crossings.
(Source: Delmonte and Tong 2011)

These solutions resulted after evaluating several dozen solutions with input from focus groups, disabled pedestrians, industry experts, and from site visits to grade crossings. The authors also suggested that such solutions be *“reviewed regularly to ensure that accessibility at level crossings for people with disabilities is continuously updated”* (Delmonte and Tong 2011, p. iv).

1.3.4 Education, Outreach, and Enforcement

Under the Rail Safety Improvement Act of 2008 (P.L. No. 110-432), the U.S. Department of Transportation developed model strategies to prevent violation of railroad related highway safety laws. These strategies fall under three broad categories: (1) expanding educational outreach, (2) energizing enforcement, and (3) fostering engineering and sight improvements. Educational outreach involves public awareness programs to help non-motorists safely navigate grade crossings. Consistent enforcement of traffic safety laws by state or local police, and a sustained effort by the courts to impose penalties on violators, discourage and deter non-motorists from making poor decisions at grade crossings. A recent report contains the latest compilation of state laws and regulations affecting highway-rail grade crossings (Jennings 2009). In addition, engineering improvements greatly prevent or reduce the potential for collisions between trains and non-motorists (USDOT/FRA 2010).

In Illinois, Operation Lifesaver began its initiative in 1976 and has since been the organization responsible for disseminating railroad safety education throughout the state. It has three areas of focus: education, enforcement, and engineering. The Illinois Operation Lifesaver (ILOS) is supported by the Illinois Commerce Commission (ICC) and is made up of 140 certified presenters. The ILOS sponsors an average of 5,000 presentations to an audience of more than 300,000 people each year (DRSC 1996). About 70% of these presentations are given to children between the ages of 5 and 18. An additional 20% focus on improving the safety awareness of drivers (DRSC 1996). ILOS also sponsors special events in Illinois, including Operation Lifesaver Safety Trains and enforcement days at commuter rail stations.

The ICC, the United States Department of Transportation (USDOT), and the Federal Railroad Administration (FRA) initiated the Public Education and Enforcement Research Study (PEERS) to measure the before and after change in the public’s adherence to traffic safety laws

(Sposato et al. 2006). The study demonstrated a reduction in crossing violations and a dramatic reduction in the most dangerous pedestrian behavior.

The study analyzed a yearlong safety program in Arlington Heights, Illinois. The program included both passive and active means of educating the public on the importance of obeying railroad crossing warning devices. Pedestrians were the focus of the program, but motorists were targeted as well. The study found that the program was successful in reducing overall highway-user violations at highway-rail grade crossings by 31%. In fact, the most risky of all violations—crossing when warning gates are fully lowered—was reduced by 71%.

Internationally, a study of a suburban railway crossing in Auckland, New Zealand (Lobb et al. 2003) looked at educational and environmental interventions to reduce illegal and unsafe crossings. The interventions included repair and treatment of fences along the corridor, educational talks given to workers at nearby factories and students at nearby schools, distribution of leaflets about the safety risk of the crossing, and new warning signs indicating the illegality and danger of crossing. The study found that after the interventions, there was a significant and sustained decrease in illegal and unsafe crossings. However, the study introduced the interventions simultaneously and therefore could not differentiate the efficacies of one intervention from the next.

In addition, in a study of interventions at a school in Auckland, (Lobb et al. (2001) examined the effect of (1) a public awareness campaign, (2) education, (3) continuous punishment and intermittent reinforcement, and (4) intermittent punishment and intermittent reinforcement. The study found a statistically significant decrease in unsafe crossings for three of the four interventions. The study did not find any significant reduction in unsafe crossings from the public awareness campaign.

1.3.5 Engineering Standards and Guidelines

The Federal Highway Administration's *Railroad-Highway Grade Crossing Handbook* (Ogden 2007) provides guidance about pedestrian crossings. Additional guidance is provided by the MUTCD (USDOT/FHWA 2009b, Part 8), American Railway Engineering and Maintenance of Way Association's (AREMA) *Communications & Signal Manual* (AREMA 2010; see Volume 1, Section 3), and *Code of Federal Regulations* 49 (see Part 234). Different standards apply to at-grade crossings of light-rail tracks, which often have no gates or warning devices. In addition, the report identifies pedestrian crossing treatments and provides recommendations for flashing light signals, "second train coming" signals, dynamic envelope markings, pedestrian automatic gates, swing gates, bedstead (maze) barriers, z-crossing channelization, and combined pedestrian treatments.

The Pedestrian Safety Guide for Transit Agencies report by the FHWA (Nabors et al. 2008) discusses at-grade and grade-separated crossings, noting that if grade-separated crossings are located at an inconvenient location, pedestrians will choose to cross at grade regardless of the safety conditions. The guide recommends specific warning times for active pedestrian warning devices. In particular, the report indicates that railroads should "provide a minimum of 20 seconds of warning time, with the active devices (bells, flashing lights, barricades, etc.) fully deployed five seconds before the arrival of a transit vehicle" (p. 33). This indicates that a pedestrian requires "a minimum of 15 seconds to complete crossing the tracks" (p. 34) and that "longer crossings may necessitate additional warning time built into the train detection system" (pp. 34–35).

The report also notes that in addition to time, the type of surface material used at the rail crossing must be designed in accordance with ADA accessibility guidelines (ADAAG). The report identifies potential infrastructure treatments including traditional gate/flasher/bell assemblies, passive and active warnings, fencing, and grade-separated crossings. The guide also indicates that surveillance, education, and enforcement can play a role in reducing instances of individuals walking on the tracks or trespassing. Additionally, the report calls for an

examination of the environment, including frequency of rail service and use of surrounding land, to identify locations in greater need of safety treatments.

At the state level, in California, CalTrain determined that there was no nationally or state recognized standard for design of a pedestrian crossing warning system on railway facilities. CalTrain developed its own design criteria and began implementing them in 1999 (CalTrain 2007). These standard practices call for active warning devices similar to those at vehicular crossings: signal equipment modified from that of vehicular crossing, crossing gate arm, and a crossing configuration that channels pedestrians. Different design criteria apply for pedestrian crossings regarding warning time, center fence, warning devices, safety buffer zone, warning assemblies, and gate recovery, as well as pedestrian crossings at stations, at stations and roadway, and crossings between roadway crossings.

In addition, also in California, the Southern California Regional Rail Authority (SCRRA, aka Metrolink) *Highway-Rail Grade Crossings Recommended Design Practices and Standards Manual* (SCRRA 2009) is a comprehensive single document that incorporates current and applicable highway-rail and pedestrian-rail grade crossing design standards and recommended design practices. The areas of interest for pedestrian-rail grade crossings include (1) pedestrian-grade separations; (2) 10-minute walk rule (proximity to schools, hospitals, and other high-density locations); (3) ADA issues; (4) refuge areas; (5) type and configuration of warning devices; (6) channelization; and (7) number of tracks. The manual notes that pedestrian treatments work well with proper channelization and signs, as well as sidewalks on either side of tracks and/or through the track area. Moreover, pavement striping continued across the track portion of roadway is an effective visual. The manual also states the importance of extra pedestrian treatments near stations for riders running to catch trains. Finally, the manual provides the decision tree shown in Figure 2 for use in determining the designs of pedestrian-rail grade crossings and appropriate warning treatments.

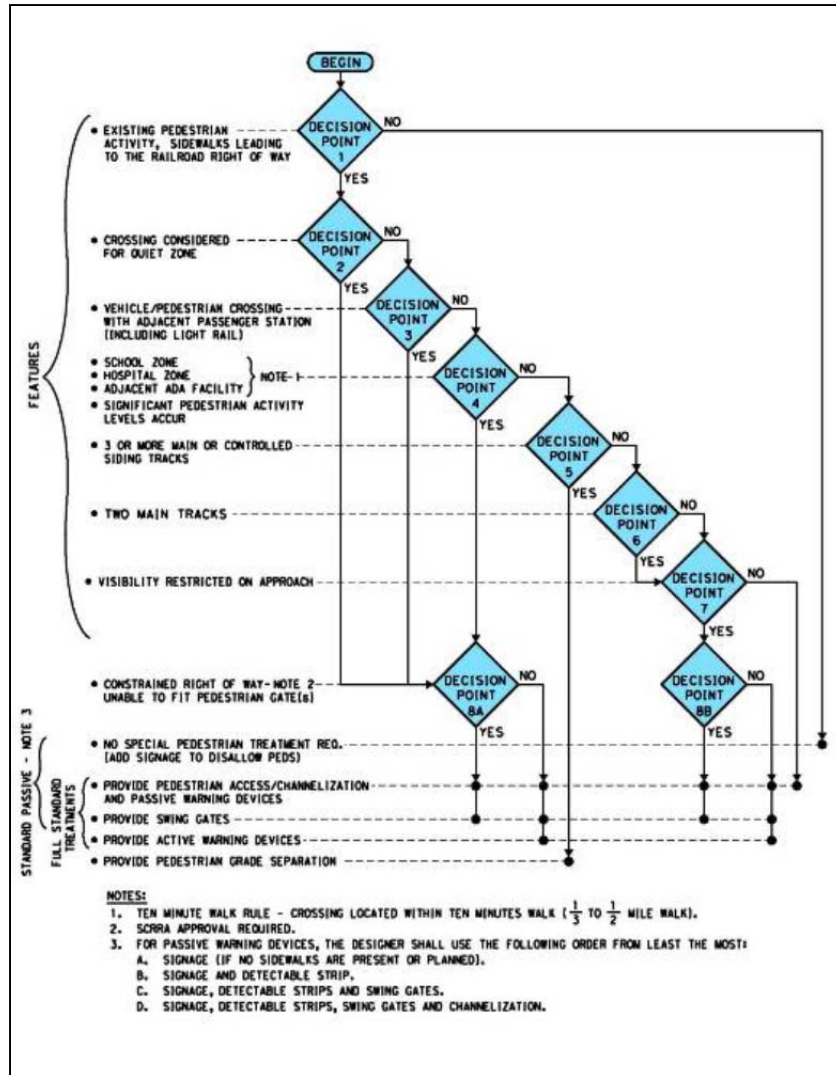


Figure 2. Pedestrian controls decision tree (Source: Korve et al. 2001, Figure 3-38).

1.3.6 Cost Considerations

A study in the United Kingdom recommended that figures obtained from a computation of costs and benefits when considering whether a safety investment should be made should not comprise, but can be used to inform, the decision-making process (U.K. Department for Transport 2006). This is because even if the cost of the improvement significantly exceeds the benefit, decision makers will consider other factors, including the tolerability of the risk to the most exposed user and any non-safety benefits that may arise from a safety improvement, before making a final decision.

The cost breakdown of the “second train coming” warning sign demonstration consisted of the following (TRB 2001):

- \$15,000 for the “second train coming” sign;
- \$80,000 for the sign installation, including track circuit modification and camera equipment;
- \$35,000 for project management and engineering; and
- \$70,000 for project evaluation.

Roop et al. (2005) argued that technologies that can likely reduce active warning costs at highway-rail crossings are those with significantly lower installation costs. In a fully redundant system, installation is one of the largest cost items of systems now in use, ranging from 25% to 35% of the total system cost. In an effort to identify low-cost systems that may provide adequate train detection capabilities while also reducing component and installation costs, the following 12 technologies were selected for evaluation: geophone, fiber optic (rail), fiber optic (buried), video imagery, radar (speed), radar (speed and distance), acoustic, pressure sensor, magnetic anomaly, infrared, and laser. Results from the analysis indicated that future research should focus on improving the safety of the acoustic and radar off-right-of-way systems.

Cost figures provided by SafeTran Systems (Petit 2001) about the cost of active warning systems offer a component breakdown showing, among other things, that for a fully redundant system, installation (labor) is one of the largest cost components, ranging from 25% to 35% of the total system cost (for Class I railroads). Train detection, on the other hand, may comprise only 20% to 25% of the total cost — and train detection is where most people think the economies are to be achieved.

Hellman and Ngamdung (2010) conducted a technology assessment of low-cost active warning devices for application at passive highway-rail grade crossings and found that many innovative right-of-way (ROW) and off-ROW prototype systems have undergone extensive testing in North America, Europe, and Australia. However, a variety of technical, economic, and institutional issues must be overcome before these technologies are considered mature enough to be adopted by railroads and government regulatory agencies. In addition, the study reported that in recent years, regulatory bodies have become increasingly sophisticated in their knowledge of non-conventional train detection and warning technologies. This is reflected in the growing use of performance-based regulations, which offer more flexibility for railroads and railroad suppliers to demonstrate safety.

1.3.7 Requirements for Warning Devices at Pedestrian-Rail Grade Crossings

The American Public Transportation Association (APTA) provides guidance for rail transit systems for selecting, installing, and operating highway-rail transit grade crossing warning systems, and includes minimum requirements for highway-rail grade crossing warning devices, highway traffic signs, and other highway traffic control appliances (APTA 2007). Regarding pedestrians at rail grade crossings it is recommended that:

- Alternative warning times may be authorized for special conditions such as near-side station stops. For these conditions, the train operator shall be able to stop the train prior to entering the intersection until it is verified that the warning system is active, and if so equipped, gates are in the fully horizontal position, and that the intersection is clear of highway and/or pedestrian traffic.
- Where near-side station stops are adjacent to interconnected traffic signal controlled intersections, accommodations must be made to ensure adequate pedestrian and vehicle clearance intervals are provided.
- Preemption may be used to clear highway vehicles and pedestrians from the trackway during the time the crossing warning system is activated, prior to the rail transit vehicle entering the crossing.

1.3.8 Guidelines for Non-Motorists at Rail Grade Crossings

USDOT/FHWA guidance on traffic control devices at rail grade crossings includes non-motorist considerations (USDOT/FHWA 2002). Because of the unique characteristics of each individual crossing, the guidelines should not be considered a warrant or standard. Therefore, selection decisions must be made based on engineering studies. In this context, the USDOT/FHWA guidance recommends that ***non-motorist-crossing safety should be considered at all rail grade crossings***. In addition, passive and active devices may be used to

supplement highway-related active control devices to improve non-motorist safety at rail crossings. These devices should be considered at crossings with high-pedestrian traffic volumes, high train speeds or frequency, extremely wide crossings, complex highway-rail grade crossing geometry with complex right-of-way assignment, school zones, inadequate sight distance, and/or multiple tracks. Finally, all pedestrian facilities should be designed to minimize pedestrian crossing time, and devices should be designed to avoid trapping pedestrians between sets of tracks.

The California Public Utilities Commission (CPUC) has published extensive design guidelines for pedestrian-rail crossings within the state of California (CPUC 2008). Their review of design considerations and installations includes recommendations for swing gates, detectable warnings, pedestrian gates, flashing light signal assemblies, signage, crossing surfaces, channelization design, and other treatments. Signage must conform to the state MUTCD. The report makes a particular reference to the Transportation Research Board's TCRP Report 69 Section 3.8.3 (Korve et al. 2001), which provides a decision tree as a tool to determine appropriate pedestrian-rail at-grade crossing treatments (shown in Figure 2 of this report). The tool has been adopted by TriMet in Portland, Oregon, but otherwise has not been validated by research (private communication with Brent Ogden, one of the co-authors of the study, 11/17/2011). Additional reference is made to a risk-scoring methodology to evaluate safety factors at station pedestrian crossings used in the United Kingdom (U.K. Department for Transport 2006).

Transport Canada (2007) has published a guide as a reference for improving pedestrian safety through assessments and the use of engineering countermeasures, as well as other safety-related treatments and programs that involve a community. A recommended approach to improving pedestrian facilities at grade crossings within a municipality is to develop a prioritization process based on objective data about each location's proximity to pedestrian attractors and risks. It is further recommended that the road authority work with the railway company to get some of the train-related data. In determining the solution most suited to a particular crossing location, a number of factors should be considered, including pedestrian traffic, site condition, accident history, and frequency of inclement weather. Various recommended solutions include marked pedestrian pathways, treatment of the approaches to the crossing surface, adult crossing guards, warning signs and/or signals, slow-down devices (e.g., swing gates or maze barriers), guide fencing, pedestrian refuge, and escape routes.

A risk-assessment methodology for pedestrian grade crossings is part of the Australian Level Crossing Assessment Model (ALCAM) still under development (Ford and Heneker 2004; Spicer 2007). The model is an assessment tool used to identify key potential risks at level crossings and to assist in prioritizing railway level crossings according to their comparative safety risk. ALCAM uses a scoring algorithm that considers each level crossing's physical properties (characteristics and controls), including the related common human behaviors, to provide each level crossing with a likelihood factor score. This score is then multiplied by the level crossing exposure score (a factor taking into account the volume of vehicles/pedestrians and trains) and finally multiplied by the consequence score (which is set at 1 for pedestrians) to give the ALCAM risk score.

The ALCAM model is designed to apply to both active and passive grade crossings, whereas the Risk Assessment of Accident and Incident at Level crossings (RAAILC) model can be used for predicting accidents at passive level crossings only. The Rail Safety and Standards Board (2007) in the United Kingdom categorized ALCAM under a simple weighted factor and RAILC as a statistically driven approach (Little 2007b). In his 2007 review, Little found only the following four operational models that take into account the number of pedestrians using the crossing (Little 2007b):

- The Automatic Level Crossing Risk Model;
- The All Level Crossings Risk Model (ALCRM);

- The Australian Level Crossing Assessment Model (ALCAM); and
- The Risk Assessment and Investment Appraisal.

Newer approaches based on simulation methods such as Petri nets are still developing (Ishak et al. 2010).

1.3.9 Intelligent Grade Crossings

Interesting new developments in the area of cooperative ITS may bring to bear applications that could dramatically affect safety for non-motorized users at grade crossings in the not so distant future. Vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and vehicle-to-consumer devices (V2D) are being developed to deliver more safety mobility benefits. Pedestrians and non-motorized users will be able to receive personalized advance warnings of incoming trains at rail grade crossings in time to avoid injuries and fatalities.

1.4 CONCLUSIONS

Communities and railroads have installed various warning devices for non-motorized users at rail grade crossings including signage (e.g., highly reflective passive warning signs, dynamic signs), pavement markings, detectable warnings (e.g., audible tones, verbal messages, and/or vibrating surfaces), channeling pedestrian traffic (e.g., different types of fencing, swing gates, zigzag/Z-gates), audible/visual warnings (e.g., low-rise flashing pedestrian signals, multi-use path flashing light signals), automatic pedestrian gates (e.g., short gate arms), and “second train coming” electronic warning signs.

A number of criteria are used to select warning devices for deployment at pedestrian-rail grade crossings, including pedestrian collision experience at the crossing, frequency of inclement weather, pedestrian volumes and peak flows, train speeds, numbers of trains, railroad traffic patterns, surrounding land uses, sight distance for pedestrians approaching the crossing, skew angle of the crossing relative to the railroad tracks, existence of multiple tracks, vicinity to a commuter station, and installation/maintenance costs. Furthermore, to discourage ***trespassers at or in the vicinity of grade crossings***, communities use fencing, landscaping, prohibitive signs, video monitoring, education/outreach, and enforcement. However, very few existing methodologies allow for assessing trade-offs among those factors during the selection process, and the potential of newer approaches is not well understood.

CHAPTER 2 INTERVIEWS WITH STATE AGENCIES AND INDUSTRY PROFESSIONALS

2.1 INTRODUCTION

We conducted 25 telephone interviews with staff at 21 state departments of transportation and commissions with jurisdiction over transportation and rail crossings, in particular. We also sought to capture information from professionals who have had a long tenure consulting on railroad level crossing safety. The interviews used a structured questionnaire instrument (Appendix A) that was approved by the study's Technical Review Panel (TRP). The purpose of the interviews was to obtain information about (1) additional relevant literature that could not be located in the literature search discussed in Chapter 1 (e.g., internal studies, consultant reports); (2) agency experiences with planning, implementation, and evaluation of warning devices under study; (3) cost estimates and/or actual costs of such warning systems; and (4) policies for use of warning signs for non-motorized users at grade crossings.

2.2 SURVEY PROTOCOL

We developed a survey questionnaire based on the findings from the literature review in Chapter 1. The survey instrument was revised to include comments from the project's TRP and was submitted for approval to the UIC Institutional Review Board (IRB), which was granted on March 29, 2011.

We obtained contact names from the project's TRP and emailed those contacts an invitation to participate in the survey (Appendix A). Once the invitation was accepted, we emailed the questionnaire along with the consent form (Appendix A) and agreed on a date and time to conduct the interview. In some cases, the contacts requested that their responses be emailed back to us, which we accepted upon consultation with the project's TRP.

At the agreed-upon date and time, we contacted the survey participants, ensured we had received a signed consent form, and obtained an additional verbal consent to record the interview. Upon completion, the interview was stored on a secured server and was later transcribed in an electronic document.

In the following discussion, we have intentionally avoided any type of comparison among peer agencies and industry experts and have done our best to shape the information from the conversations into relevant and coherent essays.

2.3 FOCUS AREAS FOR IMPROVING PEDESTRIAN SAFETY

In the public sector, we spoke with two U.S. DOT and 25 experts at 21 state departments of transportation and public utility commissions with jurisdiction over transportation and rail crossings. In the private sector, we spoke with eight professionals who have had a long tenure consulting on railroad level crossing safety. A more detailed discussion of the issues discussed is presented in Appendix A. The discussion in this chapter focuses on several general themes that we believe emerged from these interviews, which, in turn, seemed to raise a number of issues regarding safety at pedestrian-rail highway grade crossings. Some of the issues presented have already been recognized by national and international experts at research workshops (Carroll et al. 2010). Other issues presented have not been encountered regularly at public forums. Nevertheless, increasing the awareness of stakeholders in the thematic areas and issues discussed in this chapter could only help advance pedestrian safety at rail grade crossings.

2.3.1 Prioritization of Safety Upgrades

Safety upgrades are usually prioritized based on a diagnostic review process that examines a number of criteria (e.g., number of tracks, engineering design, number of trains, train speed). Decisions are usually based on a consensus among relevant stakeholders representing all groups with responsibility for the safe operation of crossings (Ogden 2007). However, safety upgrades at dedicated pedestrian crossings are often not eligible for funding, compared with those at highway-rail grade crossings, unless the two types of crossings are adjacent to each other (e.g., adjacent sidewalks on one or either side of a highway-rail crossing extending to the other side of the tracks).

2.3.2 Engineering Standards

States with substantial passenger, commuter, and freight rail operations are leading the effort to develop guidelines and engineering standards for safety improvements. Moreover, it is likely that pedestrian safety at rail grade crossings will benefit in the longer term by the increasing consistency in standards for warning devices and treatments among organizations responsible for this task. As an example of standards consistency, the definition of advance preemption in MUTCD looks the same as the one in AREMA and Institute of Transportation Engineers (ITE) documents, as well as in APTA standards.

The requirement for extra warning time for pedestrians and motorists at grade crossings of high-speed rail operations is emerging as an additional issue for safety upgrades at such crossings. Currently, the typical warning time at crossings where pedestrians may be present is between 20 and 30 seconds for conventional-speed trains. In an environment with 110-mph hour trains, there would be a need to provide confirmation signals to the train crew and the onboard computer that the crossing is clear, which would likely require a warning time of at least 80 seconds. The question about how pedestrians will react to such extended warning times at pedestrian crossings remains to be determined. This is because, currently, most of the warning time is built into the time that the train occupies the crossing. When high-speed trains begin to operate, most of the warning time is going to be built into the time for the train approaching the crossing. Therefore, an extended warning time would be necessary when the crossing remains unoccupied and a high-speed train could not be seen on the horizon. This situation will require reeducation of the public, especially in areas where crossings are very near to each other.

2.3.3 Reliability of Cost Estimates

Cost estimates and/or actual costs of the warning systems already installed are not readily available despite federal requirements under the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) program (formerly known as Section 130). This is probably because such funds are usually absorbed into much larger projects (e.g., grade separation). Moreover, a cost breakdown for design, installation, component maintenance, and operating costs is rarely finalized because the actual costs keep changing as they move from the planning stage to the design stage to the design and build stage. Additional reasons are presented elsewhere (Roop et al. 2005).

Such difficulties, in addition to the lack of dedicated funding for cost-effectiveness studies, result in a general lack of information about the cost effectiveness of pedestrian safety treatments. On the other hand, given that the number of fatalities at grade crossings is relatively low, it would be very difficult to assign a cost-effectiveness value to a particular treatment. In any case, cost oversight from state departments of transportation may be necessary to effectively manage targeted funding for safety improvements at grade crossings.

2.3.4 Funding Availability

The vast majority of funding available for safety improvements is for highway-rail crossings; very rarely are these funds exclusively for dedicated pedestrian grade crossings. It is

critical that Section 130 funding remain exclusive to railroad safety and not rolled back with other highway funds. Continuing this source of support will help maintain the level of expertise for rail safety at the FRA as well as at state departments of transportation.

2.3.5 Selection Criteria

A number of criteria are used for the selection of warning devices for deployment at pedestrian-rail grade crossings, including pedestrian collision experience at the crossing, frequency of inclement weather, pedestrian volumes and peak flows, train speeds, numbers of trains, railroad traffic patterns, surrounding land uses, sight distance for pedestrians approaching the crossing, skew angle of the crossing relative to the railroad tracks, multiple tracks, vicinity to a commuter station, and installation/maintenance costs. Furthermore, to discourage trespassers at or in the vicinity of grade crossings, communities use fencing, landscaping, prohibitive signs, video monitoring, education/outreach, and enforcement.

However, very few existing methodologies allow for assessing trade-offs between these factors during the selection process (e.g., similar in functionality to the FRA's accident prediction formula), and the potential of newer approaches is not well understood. Despite the absence of a formal process for evaluating cost effectiveness, it is, in practice, seen as a consensus-building exercise among the diagnostic team members.

A way to formalize this process would be to ask, first, whether the particular crossing under consideration may be closed or consolidated with neighboring crossings. This is an important decision because a crossing closure may be helpful to limiting the number of automobile exposures but is nearly ineffective in limiting pedestrian exposures. Unless additional measures to prevent pedestrian use are taken, pedestrians would likely continue to cross where they always have, except now as trespassers. Once such considerations have been resolved, the process would continue with an examination of the cost of various safety treatment options available compared with the expected benefits.

2.3.6 Lack of Accessible Pedestrian Signals

The lack of accessible pedestrian signals at pedestrian-rail grade crossings is mainly due to the shortage of dedicated funding for such crossings. Such signal treatments need not convey the type of messages necessary at regular intersection street crossings with more complicated traffic patterns. Occasionally, there are situations in grade crossing improvement projects where certain options are not available. For example, in the absence of adequate right-of-way, it usually becomes impossible to produce accessible sidewalks of the proper ADA width. Another reason for the infrequent use of accessible signals (other than detectable strips and detectable yellow tiles just ahead of the pedestrian gates) at rail grade crossings is the lack of standardization among manufacturers.

2.3.7 Education and Enforcement Campaigns

Strong local advocacy is probably the most important factor other, than adequate funding availability, behind effective education, outreach, and enforcement safety campaigns at pedestrian-rail grade crossings. Such campaigns should continue unmitigated, with additional service improvements in different geographic locations. Furthermore, campaigns for light-rail grade crossing safety can be relatively more effective with the active participation of a transit agency and a captive local audience exposed to the frequency of transit operations.

2.3.8 Risk Management

There is no consistent approach for managing as well as quantifying the risk at pedestrian-rail grade crossings that could ensure (1) the uniformity and continuity of data collection programs and administration of related databases on all such crossings; (2) the analysis of risks at such crossings; (3) the prioritization of crossing upgrades; (4) the introduction of suitable risk controls; and (5) the assessment of cost effectiveness of such

measures. Perhaps the FRA could promote a national campaign to this end with all states committing to the approach.

Experts seem to agree on a five-point program of risk management (informally called the five E's — Enabling, Education, Engineering, Enforcement, and Evaluation) to increase safety at pedestrian (and vehicular) rail grade crossings. "Education", "Engineering", and "Enforcement" are the key underlying principles of Operation Lifesaver in the United States. "Enabling" was added during formation in Britain of the National Level Crossing Safety Group (NLXSG) in 2002. "Enabling" is concerned with providing resources, people and systems to facilitate progress with improving level crossing safety (Little 2007a). "Evaluation" was added more recently and has become of particular interest in Europe where attention is being paid to developing common reporting methods for level crossings (i.e., types of crossings, numbers, and risk measurement) and measuring the effectiveness of programs. Little (2007a) defined the five E's as follows:

- Enabling: The provision of resources through people, procedures, and systems to allow the other E's to be effective.
- Education: Increasing public awareness of the dangers of crossings and educating pedestrians, road vehicle drivers, and other users how to use them correctly.
- Engineering: The protection fitted to level crossings through lights, horns, barriers, telephones, and signs together with research into innovative means of increasing safety.
- Enforcement: The use of laws to prosecute those who endanger themselves or others by misuse of crossings.
- Evaluation: The idea as envisaged by the NLXSG is to encourage organizations to set a baseline before embarking on new initiatives so that the before and after can be properly compared.

2.3.9 Public and Private Stakeholder Responsibilities

Determining the most suitable mix of safety upgrades at pedestrian crossings is a challenging issue complicated by the fact that regulatory authorities make the selection while the operating railroads are responsible for the installation and life-cycle costs. The public authority is interested in selecting the most robust technology available to maximize the public investment in the long run. On the other hand, the private railroad is looking to minimize the life-cycle costs of a technology that is likely to become obsolete before the end of its life and thus be expensive to maintain.

2.3.10 Quiet Zones

Non-motorized users at grade crossings within quiet zones may not receive safety benefits comparable to motorists. As a result, distracted non-motorists may not be sufficiently alerted to an incoming train, especially when a second train is coming from the opposite direction.

2.4 CONCLUSIONS

The discussion with the experts summarized in this chapter (and detailed in Appendix A) will inform researchers and practitioners involved with pedestrian safety at rail grade crossings on a number of issues.

- As consistency of engineering standards improves, it becomes important to monitor the impact on pedestrian safety.
- High-speed passenger rail service requires reeducation of pedestrian users regarding safety impacts at or in the vicinity of or away from grade crossings.

- It is increasingly important to better track programming and expenditures for safety upgrades at grade crossings.
- To facilitate the activities of a diagnostic team, there will be a need to develop a process to evaluate cost effectiveness.
- It is important to address the needs of users with disabilities at grade crossings to better manage the risk for catastrophic incidents.
- Continuation of adequate funding for strong local advocacy of education and enforcement activities is critical to pedestrian safety.
- Development of an appropriate risk management approach will better support the planning, programming, and implementation of safety upgrades at pedestrian grade crossings.

CHAPTER 3 SURVEY SITE SELECTION / IDENTIFICATION OF “HOT SPOTS”

3.1 INTRODUCTION

One of the objectives of the study was to conduct a relative comparison of the effectiveness of existing warning signs and devices at crossings used by non-motorized users. This objective was accomplished through a survey and video monitoring of user perceptions and behavior pertaining to pedestrian safety at grade crossings, as discussed in later chapters. In this chapter, we document the methodology to select the crossings of interest and provide a description of the operational environment of each selected crossing.

3.2 SELECTION OF CROSSING LOCATIONS

3.2.1 Initial Screening of Crossings

Of the 1,665 public highway-rail crossings and pedestrian pathway-rail crossings in northeastern Illinois, the ICC selected 85 locations as potential survey sites for this research. The process to obtain a roughly 5% sample ($85 \text{ of } 1665 = 5.1\%$) was as follows:

1. A first screening of crossings identified those that had a pedestrian surface based on ICC's 2005 inventory. If a crossing did not have a pedestrian surface, or the location was not a Metra depot, then the crossing was excluded from selection pool. This criterion was met by 1,215 crossings out of 1,665 locations.
2. A second criterion was used to select crossings, both pedestrian and highway, that had a collision history of two or more collisions in the past 5 years (2006–2010). This criterion was met by 42 out of 1,665 crossings, 11 of which did not have pedestrian surfaces (first criterion). Therefore, 31 of the multi-collision locations and 2 with just a single collision met both criteria.
3. An additional 14 locations were included because they are considered high-volume locations with unique pedestrian characteristics, most of which met the criteria in items 1 and 2.
4. The 33 collision “hot spots” in item 2 and the 14 crossings in item 3 accounted for 40 locations. An additional 45 locations were selected based on the following criteria:
 - a. Given a mix of 90% out of 1,665 highway crossings and 10% (161 out of 1,665) pedestrian-only crossings, it was desirable not to have too many pedestrian-only crossings (say, no more than a 20% to 80% split).
 - b. It was also desirable that survey sites have at least 20 trains per day (preferably more) to ensure that enough observations could be collected per location.
 - c. Additionally, the candidate sites should have significant AADT volumes at highway-rail crossings, assuming this would translate into significant volumes of pedestrian activity (more than 40 of 67 highway crossings have AADT of at least 5,000).
 - d. The crossing locations should be approximately equally distributed spatially in the six-county region, including a balance between the City of Chicago and its suburbs.
 - e. The candidate sites should be approximately equally distributed by rail line (there are about 25 primary rail lines in the region).
 - f. Similarly, the crossings should be approximately equally distributed by railroad (there are nine primary operating railroads in the six-county region).
 - g. There should be a mix of train types with freight only, Metra only, and a Metra/Amtrak combination.

- h. There should be a balance between crossings within quiet and non-quiet zones. This represents about a 50/50 split, which is an oversampling of quiet zone crossings but hard to avoid because most of the busier line segments are quiet zones.
- i. The selected locations should include a mix of state route locations and non-state route locations for the 68 highway-rail crossings (roughly 20% are on state routes).

An effort was made to achieve a balance by warning device type because about 80% of all crossings have train-activated warning devices and 20% rely on signs only, such as crossbuck or stop signs. This did not work out so well because most of the crossings with significant train and highway volume have train-activated warning devices.

3.2.2 Final Crossing Selection

Of the 85 pedestrian crossings chosen by this project's TRP, we selected 10 at which to conduct surveys and video monitoring. The selection was initially made using the FRA's accident prediction formula (APF) values for the associated highway-rail grade crossing (APF values show the chance, as a percentage, of an accident occurring at that crossing in the next 12 months; high-risk crossings have an APF value ≥ 0.05). The reason for exploring use of the APF and not observed frequencies of accidents is that the latter cannot be deemed as being high or low in the absence of a benchmark. The APF provides an estimate of the expected number of collision incidents for each crossing that takes into account vehicular and train flows. This estimate can then be used as a benchmark against observed collision frequencies.

The APF does not include pedestrian flows as an input into the estimation process; therefore, a crossing cannot be assigned a separate risk index for vehicular and pedestrian incidents. However, the majority of pedestrian collision incidents occur at highway-rail crossings vis-à-vis at dedicated pedestrian crossings. It is reasonable, therefore, to assume that at least some of the environmental factors that serve as input into the APF process remain relevant for incidents involving non-motorized users.

With additional input from the TRP, we selected six crossings with high APF values, four of which had the highest number of collisions and two with no collisions between 2006 and 2010. Four additional crossings, one of which was a dedicated pedestrian crossing, in the path of Metra, Amtrak and freight operations were also selected. All 10 locations selected and shown in Table 1 had a high exposure of non-motorized users to rail traffic and allowed acquiring a sufficient amount of data from surveys.

3.3 DESCRIPTION OF SELECTED LOCATIONS

We conducted field inspections of the 10 selected crossings to become familiar with the crossing environment. The findings of this activity are described below and provide background information for survey activities discussed in later chapters.

Table 1. Selected Crossings and Operational Characteristics

| US DOT Inventory No. | County Name | City Name | Railroad Line (Operator) | Operating Railroad (Type of Train) | Street Name | Crossing Type and Pedestrian Warning Device | 2006–10 Collision History |
|----------------------|-------------|--------------|--------------------------|-------------------------------------|----------------------|--|---------------------------|
| 608830M | Cook | Chicago | NIRC RIM (Metra) | Metra (Metra only) | 119th St | Highway-rail crossing with no pedestrian gates | 0 |
| 079493L* | Cook | Riverside | BNSF A (Amtrak & Metra) | BNSF (Metra, Amtrak, Freight) | ILL43/Harlem Ave | Highway-rail crossing with pedestrian gates | 3 |
| 173887G* | Cook | Chicago | UP CNWO (Metra) | UP (Metra, Freight) | Nagle Ave | Highway-rail crossing with pedestrian gates | 5 |
| 079508Y* | Cook | La Grange | BNSF A (Amtrak & Metra) | BNSF (Metra, Amtrak, Freight) | US12/La Grange Rd | Highway-rail crossing with pedestrian gates | 3 |
| 174948Y* | DuPage | Glen Ellyn | UP CNWA (Metra) | UP (Metra, Freight) | Park Blvd | Highway-rail crossing with pedestrian gates | 0 |
| 843811C | Cook | Chicago | BRC M | Belt Railway Company (Freight only) | Marquette Rd | Highway-rail crossing with pedestrian gates | 0 |
| 388040W | Lake | Deerfield | NIRC A (Amtrak & Metra) | Metra (Metra, Amtrak, Freight) | Osterman Ave | Highway-rail crossing with pedestrian gates | 0 |
| 079521M | DuPage | Hinsdale | BNSF A | BNSF (Metra, Amtrak, Freight) | Ped/Park St | Stand-alone pedestrian crossing with gates | 0 |
| 174937L* | DuPage | Villa Park | UP CNWA (Metra) | UP (Metra, Freight) | Ped/Villa Park Depot | Pedestrian crossing with pedestrian gates, another train-warning sign and channelization | 0 |
| 372128W* | Cook | Elmwood Park | NIRC L6 (Metra) | Metra (Metra, Freight) | Ped/Elmwood Pk Depot | Platform crossing with pedestrian flashers | 0 |

*High-risk crossing with an APF value ≥ 0.05 .

| Selected Operational Characteristics | | | | | | | |
|--------------------------------------|-------------------|------------------|--------|--------|-------------------|----------------------------|------------------|
| US DOT Inventory No. | Daily Train Total | Passenger Trains | AADT | Tracks | Track Speed (mph) | 2006-10 Pedestrian Crashes | Pedestrian Gates |
| 608830M | 47 | 47 | 21,300 | 2 | 30 | 0 | 0 |
| 079493L* | 171 | 112 | 29,900 | 3 | 70 | 0 | 4 |
| 173887G* | 68 | 64 | 15,400 | 3 | 70 | 1 | 4 |
| 079508Y* | 156 | 104 | 20,600 | 3 | 70 | 1 | 4 |
| 174948Y* | 108 | 64 | 7600 | 3 | 70 | 0 | 4 |
| 843811C | 24 | 0 | 14,200 | 3 | 30 | 0 | 4 |
| 388040W | 96 | 78 | 3,800 | 3 | 79 | 0 | 3 |
| 079521M | 156 | 104 | N/A | 3 | 70 | 0 | 2 |
| 174937L* | 108 | 64 | 10,400 | 3 | 70 | 0 | 4 |
| 372128W* | 128 | 78 | 8,700 | 3 | 70 | 0 | 0 |

3.3.1 Crossing 608830M

Crossing 608830M (Figure 3) is a double-track highway-rail grade crossing on 119th Street with pedestrian approaches on both sides of the roadway that continue to the other side

of the tracks. There are no pedestrian gates on the attached sidewalks. The sidewalk quality at the crossing location varies along 119th Street and worsens to the east where the nearest neighbor crossing is located. The sidewalk appears to be damaged at one point, while at another stretch it is laid with gravel rather than paved.

The crossing is located near the busy intersection of 119th Street and Vincennes Road. The plaza located at the intersection attracts a lot of pedestrian foot traffic, as does the CTA bus and Metra stops (see Appendix H for a ground view). This intersection is in close proximity to I-57 and a fairly new shopping mall, which is likely a major attractor of vehicular traffic in the area.

The intersection also contains a large, vacant, barricaded lot adjacent to the Metra stop. The lot characterizes a barren zone, overgrown with weeds and debris that discourage walk-through as an improvised shortcut. Overall, this is a mixed-use area because it accommodates both residential and business owners. Existing townhomes appear to generate light traffic flow.



Figure 3. Crossing 608830M—A view above ground.
(Source: Google Earth 2010)

3.3.2 Crossing 079493L

Crossing 079493L (Figure 4) is a triple-track highway-rail grade crossing on Harlem Avenue. There are pedestrian approaches on both sides of Harlem Avenue that continue on the other side of the tracks. There are pedestrian gates on all four quadrants of the attached sidewalks.

The crossing is located near the intersection of Harlem and East Avenues. This is a high-vehicular and high-pedestrian traffic area. This mixed-use neighborhood (see Appendix H for a ground view) caters to business and home owners alike. Retail stores as well as housing units exist on the same block. Harlem Avenue is the commercial corridor welcoming drivers into the Village of Berwyn. The rail crossing is also located near I-290.

At the nearby road intersection, the food mart/gas station generates both pedestrian and vehicle traffic. Restaurants, bars, and lounges line Harlem Avenue, along with many banks, clothing stores, and community plazas. At varying pockets throughout the entire corridor, one might see the multi-floor, high- and low-rise, mixed-use residential and business units that characterize the corridor and generate its liveliness.



Figure 4. Crossing 079493L—A view above ground.
(Source: Google Earth 2010)

3.3.3 Crossing 173887G

Crossing 173887G (Figure 5) is a triple-track highway-rail grade crossing on Nagle Avenue (see Appendix H for a ground view). There are pedestrian approaches on both sides of Nagle Avenue that continue on the other side of the tracks. There are pedestrian gates on all four quadrants of the attached sidewalks.

The crossing is very near the intersection of North Nagle Avenue and Northwest Highway, which runs parallel to the rail tracks. There is a CTA bus stop located right outside a food mart/gas station. The neighborhood is mixed use, catering to business and residential occupants. There is a nearby fenced self-storage facility on the Northwest Highway while, on the opposite side of the highway, residential housing units generate additional pedestrian traffic.



Figure 5. Crossing 173887G—A view above ground.
(Source: Google Earth 2010)

3.3.4 Crossing 079508Y

Crossing 079508Y (Figure 6) is a triple-track highway-rail grade crossing on South La Grange Road. There are pedestrian approaches on both sides of La Grange Road that continue on the other side of the tracks. There are pedestrian gates on all four quadrants of the attached sidewalks.

The crossing is near the intersection of Burlington Avenue and La Grange Road and is in close proximity to the neighboring shopping district (see Appendix H for a ground view). The area generates considerable vehicle and pedestrian traffic, which is amplified during the holiday seasons. The franchise restaurants, bookstore, and Walgreens seem to be the main generators of pedestrian traffic.



Figure 6. Crossing 079508Y—A view above ground.
(Source: Google Earth 2010)

3.3.5 Crossing 174948Y

Crossing 174948Y (Figure 7) is a triple-track highway-rail grade crossing on North Park Boulevard in Glen Ellyn. There are pedestrian approaches on both sides of the roadway that continue on the other side of the tracks. There are pedestrian gates on all four quadrants of the attached sidewalks, as well a “second train coming” audio-visual warning device.

The crossing is next to a high school at the intersection of Crescent and North Park Boulevards. Directly across the street from the high school, there is a mixed-use business and residential building (see Appendix H for a ground view). Adjacent to the housing units, a Metra parking facility line the street clear into the next intersection.



Figure 7. Crossing 174948Y—A view above ground.
(Source: Google Earth 2010)

3.3.6 Crossing 843811C

Crossing 843811C (Figure 8) is a triple-track highway-rail grade crossing on West Marquette Road in southwest Chicago with pedestrian approaches on both sides of the roadway that continue to the other side of the tracks. The crossing had pedestrian gates with channelization (see Appendix H for a ground view).

West Marquette Road is a residential road with low volumes of pedestrian traffic and mid-level vehicle traffic, in general. During school days at the nearby elementary school in the southwest quadrant, the south sides of the crossing see a high volume of school kids. Also, in the southwest quadrant and adjacent to the crossing, a vacant lot serves as a parking for residents in the area.

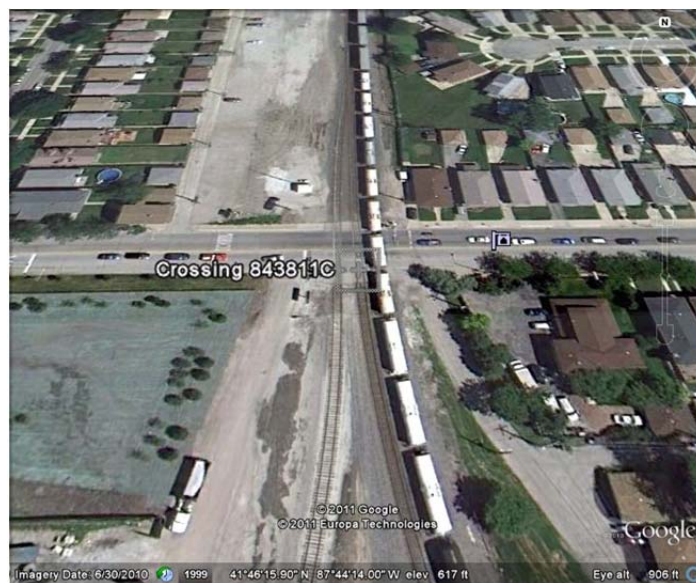


Figure 8. Crossing 843811C—A view above ground.
(Source: Google Earth 2010)

3.3.7 Crossing 388040W

Crossing 388040W (Figure 9) is a triple-track highway-rail grade crossing on Osterman Avenue in Deerfield. There are pedestrian approaches on both sides of the roadway that continue to the other side of the tracks (see Appendix H for a ground view). There are pedestrian gates on all four quadrants of the attached sidewalks.

The nearby road intersection of Elm Street and Osterman Avenue is an area of low vehicle and pedestrian traffic. It seems that a major portion of the traffic is generated by the Metra “pay to park” facility. Just west of the rail crossing, a residential development area is likely to produce additional pedestrian and vehicular traffic.



Figure 9. Crossing 388040W—A view above ground.
(Source: Google Earth 2010)

3.3.8 Crossing 079521M

Dedicated pedestrian crossing 079521M (Figure 10) is several hundred yards east of the Hinsdale Metra station near the road intersection of N.M. Symonds Drive and Park Avenue. The facility crosses a triple-track rail line. There are pedestrian gates on both sides of the tracks (see Appendix H for a ground view).

Within walking distance from the crossing is a midsize greenspace used for recreational activities. The neighboring Metra parking facility and post office generate additional pedestrian traffic using the crossing.



Figure 10. Crossing 079521M—A view above ground.
(Source: Google Earth 2010)

3.3.9 Crossing 174937L

Crossing 174937L (Figure 11) is a triple-track highway-rail grade crossing on Ardmore Street in Villa Park. There are pedestrian approaches on both sides of the roadway that continue to the other side of the tracks. There are pedestrian gates as well as “another train coming” audio-visual devices on all four quadrants of the attached sidewalks (see Appendix H for a ground view). There is also pedestrian fencing and channelization designed to direct Metra patrons away from the tracks and back to the proper approach in order to cross the crossing.

The crossing is very near the road intersection of North Ardmore and West Terrace. The area generates a stable flow of traffic, mainly due to the convenience of a local gas station. The mixed-use business and residential buildings generate additional pedestrian and vehicular traffic.



Figure 11. Crossing 174937L—A view above ground.
(Source: Google Earth 2010)

3.3.10 Crossing 372128W

Crossing 372128W (Figure 12) is a triple-track highway-rail grade crossing on 75th Avenue in Elmwood Park with pedestrian approaches on both sides of the roadway that continue to the other side of the tracks. There are no pedestrian gates on the attached sidewalks (see Appendix H for a ground view).

The nearby road intersection of 75th Avenue and West Marwood Avenue is within a mixed-use area. The stores and business along this neighborhood corridor complement the moderate volumes of pedestrian and vehicle traffic as people shop and make use of neighborhood amenities.



Figure 12. Crossing 372128W—A view above ground.
Source: Google Earth 2010)

CHAPTER 4 SURVEY OF NON-MOTORIZED USERS

4.1 INTRODUCTION

Following the selection of candidate crossing (hot spots) sites as discussed in Chapter 3, we conducted interviews of non-motorized users at each of the 10 selected crossings. The objectives of the survey were to (1) gauge user attitudes about crossing the tracks; (2) assess environmental, demographic, and socioeconomic factors that may impact the crossing behavior; and (3) attempt to quantify the effectiveness of installed signs and devices to improve safety at pedestrian-rail grade crossings. This chapter discusses the organization and implementation of the survey and the analysis of the data.

4.2 SURVEY MANAGEMENT

With assistance from the University of Illinois at Chicago (UIC) Survey Research Laboratory (SRL), we conducted an attitudinal survey of non-motorized users at the 10 highway-rail and pathway-rail grade crossings selected in Chapter 3. A UIC Institutional Review Board (IRB) exemption was granted on September 26, 2011 (IRB protocol #2011-0785), and questionnaires were completed by 312 pathway-rail and highway-rail grade crossing users between October 27, 2011, and December 31, 2011.

The SRL is a research and service unit established in 1964. It is a division of UIC's College of Urban Planning and Public Affairs. The SRL project management team consisted of (1) a project coordinator responsible for the overall coordination of project activities and communication with the UTC research team, (2) a field coordinator who provided training and direct supervision of the interviewing staff, (3) a data reduction manager who oversaw coding staff, (4) a research programmer who removed remaining inconsistencies from the data and produced data files and formats to facilitate statistical analysis, and (5) a sampling and analysis director who provided expertise for sampling procedure planning. Each member of the team participated in methodology discussions during the planning phases of the study and throughout the data collection period.

4.3 SAMPLING PLAN

Data were collected from users of 10 rail crossing sites chosen through a detailed screening process discussed in Chapter 3. To obtain a mix of pedestrian types, each site was visited at least once on a weekday and once on the weekend. On the weekdays, we started shifts early to capture the start of the morning rush hour. In locations farthest from Chicago, we started at 6:00 a.m.; in locations closer to Chicago, we started at 6:30 a.m. On weekends, we began interviewing at approximately 7:00 a.m. It was assumed that we would have lower cooperation from pedestrians in the evening because most would be on their way home.

To avoid temporal clustering of respondents by gaining the desired number of completed interviews in a short amount of time at the sites with many users, only one questionnaire was completed every 15 minutes. To achieve this, interviewers divided the 4-hour shift into 15-minute intervals. During each interval, only one questionnaire was completed. Once the interview was complete, interviewers waited until the next interval began to approach crossing users to participate. Through this process, only 16 interviews could be completed per site on an assigned day. However, at the sites with low foot traffic, we attempted interviews with all available pedestrians rather than trying to space them out over a 15-minute interval.

4.4 QUESTIONNAIRE DEVELOPMENT

The questionnaire was developed by the UTC research team and the SRL project coordinator and included all recommended revisions by this project's TRP. The paper instrument was interviewer administered, and respondents were expected to complete the

questionnaire in approximately 3 minutes. The questionnaire can be viewed in Appendix C. The final version was reviewed and modified by the SRL Questionnaire Review Committee (QRC). The QRC is composed of SRL staff members appointed by the SRL director to ensure that all questionnaires administered by SRL follow ethical practices and basic principles of questionnaire construction. No instrument is administered to respondents before approval is obtained from this committee. QRC made suggestions for modifications that focused on wording, format, and question order. Topics covered in the instrument include (1) history of pathway-rail and highway-rail use, (2) perceptions of active and passive warning devices, and (3) impairment and other background characteristics.

4.5 DATA COLLECTION

A pretest was conducted on October 13, 2011. For the pretest, one interviewer spent approximately 4 hours at one crossing location with moderate foot traffic to test the sampling plan and questionnaire. Afterward, a debriefing was held with the UTC research team to discuss an updated questionnaire and new field procedures based on the information collected.

Main data collection took approximately 9 weeks, beginning on October 27, 2011, and ending on December 31, 2011. All 10 sites had their initially scheduled weekend and weekday shifts completed by November 11. During some site visits, few pedestrians used the crossing because of poor weather conditions, so we added additional days for interviewers to revisit those sites.

By November 17, we had obtained the necessary number of completed interviews at all sites except Hinsdale and Nagle. Hinsdale and Nagle were challenging sites because neither was directly connected to a Metra rail station (the Hinsdale crossing is approximately 235 yards east of the Hinsdale Metra station) and therefore had low foot traffic. We continued to visit these sites twice a week through December 31.

4.5.1 Personnel

Before beginning work, each interviewer hired at SRL participated in a 2-day general interviewer training session that focused on basic interviewing skills, such as establishing professional rapport, answering potential questions, and maintaining cooperation of respondents. All of the interviewers chosen for this study were currently employed or were employed in the past by SRL. In addition, all interviewers and field supervisors received 4-hour, study-specific training. The training included a safety briefing, a general orientation to the design and purpose of the study, a brief overview of each crossing location, and a review of the oral screener and questionnaire. Four interviewers were trained for the study. The training was held on October 17, 2011. All field staff were supplied an interviewer training manual covering all aspects of the data collection procedures, which was used during the training session and as a reference manual throughout the course of the study.

4.5.2 Field Procedures

Each of the 10 sites was assigned one interviewer (and one back-up interviewer) to conduct both the weekday and weekend shift. Each site was visited at least once on the weekday and once on the weekend. One interviewer reported to each site between 6:00 and 10:30 a.m. on the weekday and between 7:00 and 11:00 a.m. on the weekend. As already noted, for most sites, the 4-hour shift was divided into 15-minute intervals. During each interval, only one interview was completed. Once the interview was complete, interviewers waited until the next interval began to approach crossing users to participate. Through this process, a maximum of 16 interviews could be completed per site on an assigned day.

On the weekday shift, within the scope of video collection activities (described in Chapter 5), the UTC research team set up a camera to enumerate pedestrian use at each crossing. There was only one camera available to conduct the enumeration and one interviewer scheduled at the

crossing with the camera. On the weekend shift, a UTC graduate research assistant completed the enumeration of pedestrian use at each crossing. The interviewers and student affiliates began the shift at the same time. Some sites required additional weekday and weekend visits (after 11:00 a.m.); no enumeration was conducted on these visits.

At each site, interviewers approached prospective respondents, provided a study information sheet if necessary, asked for respondents' oral consent to participate, and completed the questionnaire with respondents. Interviews were conducted only with respondents at least 18 years of age. When a prospective participant was in a rush and could not stop to complete the questionnaire, the interviewer walked alongside him/her as the questionnaire was completed. The questionnaire can be found in Appendix C; answers to common respondent questions can be found in Appendix D the oral consent form script can be found in Appendix E; and the study information sheet can be found in Appendix F.

4.5.3 Data Processing

The SRL Office of Data Reduction entered data from the completed questionnaires. One aspect of data reduction of the pen and pencil instrument (PAPI) questionnaire data was the processing of all text answers to survey items. On items with an "other-specify" response option, interviewers sometimes entered a text response that could be changed later to one of the precoded response options. All the "other-specify" responses were reviewed by the project coordinator after data collection was complete. The changes then were made by the SRL Data Reduction section in a process known as backcoding.

The SRL Data Reduction section was also responsible for producing an edited text file of all the "other-specify" and open-ended variables as a deliverable at the end of the survey. The editing consisted of regularizing spelling and capitalization, filling out abbreviations, and eliminating software-related text, such as the interviewer- and time-stamps added to each text answer. Staff from the Office of Survey Systems ensured that any illegal answers were caught and corrected and any missing data properly coded. The data sets and SPSS and SAS setup files were created at the end of the main study data collection and delivered to the UTC research team.

4.5.4 Final Disposition of Sample

We completed 312 interviews, all of which were used for analysis. The average cost per completed survey was about \$85. The final completed questionnaire outcomes per site can be seen in Table 2. Enumerated (manual or video) counts can be used to factor up to the total population of users during the time of the survey.

Table 2. Survey Responses Completed at Each Crossing Location

| US DOT Inventory No. | City Name | Street Name | 2006–2010 Collision History | Surveys Completed | | | | Enumerated | |
|----------------------|------------|-------------------|-----------------------------|-------------------|--------|-------|---------|---------------------|----------------------|
| | | | | W'kday | W'kend | Total | Percent | W'kday Video Counts | W'kend Manual Counts |
| 608830M | Chicago | 119th St | 0 | 16 | 22** | 38 | 12.2% | 114 | 121 |
| 079493L | Riverside | ILL43/Harlem Ave | 3 | 15 | 15 | 30 | 9.6% | 215 | 58 |
| 173887G | Chicago | Nagle Ave | 5 | 9* | 20** | 29 | 9.3% | 185 | 60 |
| 079508Y | La Grange | US12/La Grange Rd | 3 | 15 | 16 | 31 | 9.9% | 503 | 155 |
| 174948Y | Glen Ellyn | Park Blvd | 0 | 15 | 15 | 30 | 9.6% | 452 | 168 |
| 843811C | Chicago | Marquette Rd | 0 | 23* | 9** | 32 | 10.3% | 174 | 26 |

| US DOT Inventory No. | City Name | Street Name | 2006–2010 Collision History | Surveys Completed | | | | Enumerated | |
|----------------------|--------------|----------------------|-----------------------------|-------------------|--------|-------|---------|---------------------|----------------------|
| | | | | W'kday | W'kend | Total | Percent | W'kday Video Counts | W'kend Manual Counts |
| 388040W | Deerfield | Osterman Ave | 0 | 15* | 15 | 30 | 9.6% | 47 | 40 |
| 079521M | Hinsdale | Ped/Park St | 0 | 13* | 18** | 31 | 9.9% | 30 | 13 |
| 174937L | Villa Park | Ped/Villa Park Depot | 0 | 16 | 15 | 31 | 9.9% | 245 | 78 |
| 372128W | Elmwood Park | Ped/Elmwood Pk Depot | 0 | 15 | 15 | 30 | 9.6% | 101 | 86 |
| Totals | | | 11 | 152 | 160 | 312 | 100% | 2066 | 805 |

*Surveys completed on multiple weekdays; **surveys completed on multiple weekend days.

4.5.5 Survey Limitations

Intercept surveys by definition rely on convenience samples. We did not have a sample frame of all people who use the sampled crosswalks, so we could not calculate the probability of selection of each survey respondent. Varying the day and time of interviewing, as well as spacing the number of interviews collected in a given time period, increased the variability of the respondents sampled, but it did not guarantee that the sample was representative. Thus, one cannot draw inferences about the population from such a sample. Information gathered from these interviews pertains only to the sample included in the survey, not to the larger population of pedestrians who use these crosswalks.

We were also unable to estimate the sampling rate and the response rate from the survey. In particular, enumerated counts can be used in the estimation of a sampling rate $[(completed\ surveys + refusals)/enumerated\ counts]$. Refusals are also used in the estimation of the response rate $[completed\ surveys/(completed\ surveys + refusals)]$ to assess the magnitude and pattern of non-response bias, if any, in an intercept survey. Unfortunately, we were not able to retrieve reliable information about the number of refusals from field personnel.

Finally, we were unable to reliably verify the activation of warning devices during each of the interviews. As a result, participants were assumed to be giving answers to relevant questions based on previous experience.

4.6 SURVEY RESULTS

4.6.1 Mode of Crossing

Almost 95% of the respondents walked, while less than 4% were on bicycle (Table 3). More than 9% of walkers were listening to music on their earphones or were talking and texting on their cell phone. Finally, more than 3% of walkers were with young children or pushing a stroller. Only one out of 12 bicyclists was seen with young children.

Table 3. Mode of Crossing

| Mode | Biking | Percent All Bikers | Walking | Percent All Walkers | Not Checked or Missing | Total |
|------------------------|--------|--------------------|---------|---------------------|------------------------|--------|
| Just bicycling | 11 | 91.7% | | | | 11 |
| Just walking | | | 256 | 86.5% | | 256 |
| Walking aid | | | 1 | 0.3% | | 1 |
| Pushing cart | | | 2 | 0.7% | | 2 |
| Pushing stroller | | | 4 | 1.4% | | 4 |
| With young children | 1 | 8.3% | 5 | 1.7% | 1 | 7 |
| Music on earphones | | | 20 | 6.8% | 1 | 21 |
| On cell phone | | | 6 | 2.0% | | 6 |
| Texting | | | 2 | 0.7% | | 2 |
| Not checked or missing | | | | | 2 | 2 |
| Total | 12 | | 296 | | 4 | 312 |
| Percent | 3.8% | | 94.9% | | 1.3% | 100.0% |

4.6.2 Day and Time of Interview

Interviews were almost equally distributed between weekdays (49%) and weekends (51%). Thirty-one survey days were required to complete 312 interviews. Weekends ended up being more productive than weekdays (Table 4).

Table 4. Day of the Week

| Day of Week | Frequency | Number of Surveys | Percent of Surveys |
|-------------|-----------|-------------------|--------------------|
| Monday | 4 | 42 | 13.5% |
| Tuesday | 4 | 42 | 13.5% |
| Wednesday | 2 | 9 | 2.9% |
| Thursday | 4 | 19 | 6.1% |
| Friday | 4 | 40 | 12.8% |
| Saturday | 8 | 126 | 40.4% |
| Sunday | 5 | 34 | 10.9% |
| Total | 31 | 312 | 100.0% |

Most of the interviews were conducted between 7:00 and 11:00 a.m. (Table 5). Only one interview was conducted after 2 p.m.

Table 5. Time of Interview

| Responses | Frequency | Percent |
|--------------------|-----------|---------|
| 6 to 7 a.m. | 14 | 4.5% |
| 7 to 8 a.m. | 74 | 23.7% |
| 8 to 9 a.m. | 73 | 23.4% |
| 9 to 10 a.m. | 64 | 20.5% |
| 10 to 11 a.m. | 55 | 17.6% |
| 11 a.m. to 12 noon | 14 | 4.5% |
| 12 noon to 1 p.m. | 9 | 2.9% |
| 1 to 2 p.m. | 8 | 2.6% |
| 2 to 3 p.m. | 1 | 0.3% |
| Total | 312 | 100.0% |

4.6.3 Age and Gender of Survey Respondents

Male respondents were clearly overrepresented in the survey sample (Table 6). In five cases, the gender information was missing.

Table 6. Gender and Age of Survey Respondents

| Gender | Frequency | Percent Valid Responses |
|--------------------|-----------|-------------------------|
| Male | 176 | 57.3% |
| Female | 131 | 42.7% |
| Refused or missing | 5 | — |
| Total | 312 | 100.0% |

The distribution by age category is shown in Figure 13 (see Table 29 for age frequencies). More than twice as many male respondents 31 to 40 years old compared with their female counterparts participated in the survey. The other age categories were more evenly distributed between genders.

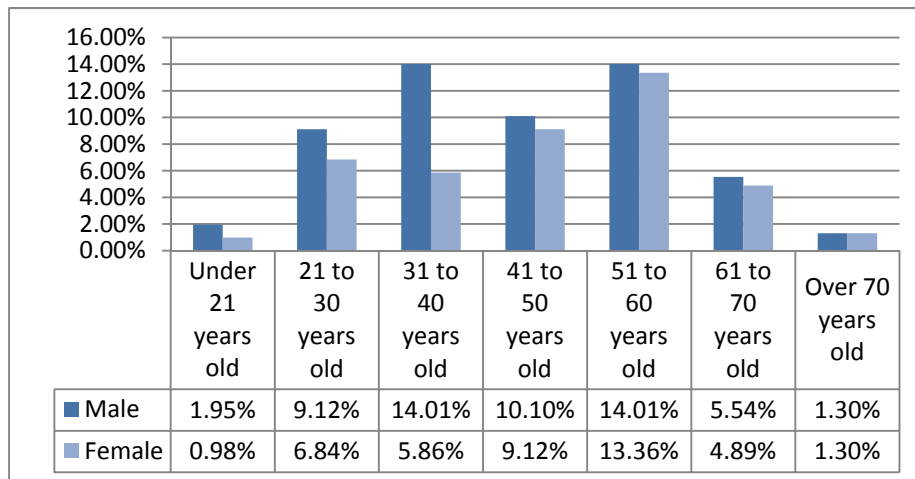


Figure 13. Distribution of survey respondents by gender and age group.

4.6.4 Q1. Frequency of Using Crossing

Users who responded using the crossing “for first time/irregularly” were classified as irregular users. Thus more than 87% (272 out of 312) of respondents were regular users of the crossing at which they were interviewed (Table 7). Nine out of ten of the regular users used the crossing on a daily or weekly basis. The mode of the daily/weekly/monthly/annual distributions of the frequency of crossing use was two times.

Table 7. Q1. Frequency of Crossing Use

| Number of Times | Daily | Weekly | Monthly | Yearly | Total | Percent |
|------------------------------|-------|--------|---------|--------|--------|---------|
| 1 | 20 | 10 | 5 | 0 | | |
| 2 | 83 | 28 | 10 | 2 | 123 | 45.2% |
| 3 | 2 | 10 | 1 | 0 | 13 | 4.8% |
| 4 | 13 | 19 | 5 | 1 | 38 | 14.0% |
| 5 | 3 | 14 | 1 | 0 | 18 | 6.6% |
| 6 | 5 | 8 | 2 | 1 | 16 | 5.9% |
| 7 | 3 | 1 | 0 | 0 | 4 | 1.5% |
| 8 | 0 | 5 | 1 | 0 | 6 | 2.2% |
| 10 | 2 | 12 | 0 | 1 | 15 | 5.5% |
| 12 | 0 | 1 | 0 | 0 | 1 | 0.4% |
| 14 | 0 | 2 | 0 | 0 | 2 | 0.7% |
| 15 | 0 | 1 | 0 | 0 | 1 | 0.4% |
| Total | 131 | 111 | 25 | 5 | 272 | 100.0% |
| Percent | 48.2% | 40.8% | 9.2% | 1.8% | 100.0% | |
| First Timers/Irregular Users | | | | | 40 | |
| Total | | | | | 312 | |

4.6.5 Q2. Warning Signs and Devices Awareness

User awareness of warning signs (always a passive type of warning) and warning devices (always an active type of warning) is discussed in this section. Note that the warning devices may or may not have been actually activated when the survey question was being asked. As a result, we could not distinguish between the activation states of a warning device and its parallel ability to be observed by the survey respondent.

Almost one in six respondents (56% of whom were male) did not notice any warning signs or warning devices (Table 8). Age appeared to be a contributing factor. For example, 25% of respondents over 70 years old did not notice any warning signs or devices compared with just 9% of those between 61 and 70 years old who topped all other groups in sign awareness. Users under 21 (22%) and between 21 and 30 years (20%) were the next two age groups with reduced awareness. In addition, 35% of irregular users showed reduced awareness of warning signs and devices compared with 15.1% of regular users.

Awareness of warning signs and devices varied by the time period of the day. For example, the top three time periods of the day with reduced awareness were 11:00 a.m. to 12:00 noon (29%), 12:00 noon to 1:00 p.m. (22%), and 9:00 to 10:00 a.m. (20%). Lack of awareness in (presumably) complete daylight implied that distraction may have been at play.

Table 8. Q2. Noticed Signs or Warning Devices at Pedestrian Crossing

| Responses | Frequency | Percent |
|----------------|-----------|---------|
| Did notice | 257 | 82.4% |
| Did not notice | 55 | 17.6% |
| Total | 312 | 100.0% |

Indeed, discrepancy in awareness among different types of users is telling (Table 9). For example, 50% of respondents on cell phones indicated they had not noticed a warning sign or a device. Among users listening to music on earphones or pushing a stroller, one in four showed a lack of relevant awareness. Moreover, one in five walkers and one in twelve bicyclists showed a similar trait (see survey limitations in earlier section).

Table 9. Sign/Warning Device Awareness by Type of User

| Responses | Noticed | Percent | Did Not Notice | Percent | Total |
|---------------------|---------|---------|----------------|---------|-------|
| Walking | 242 | 81.8% | 54 | 18.2% | 296 |
| Music on earphones | 16 | 76.2% | 5 | 23.8% | 21 |
| Bicycling | 11 | 91.7% | 1 | 8.3% | 12 |
| With young children | 7 | 100.0% | 0 | 0.0% | 7 |
| On cell phone | 3 | 50.0% | 3 | 50.0% | 6 |
| Pushing stroller | 3 | 75.0% | 1 | 25.0% | 4 |
| Pushing cart | 2 | 100.0% | 0 | 0.0% | 2 |
| Texting | 2 | 100.0% | 0 | 0.0% | 2 |
| Walking aid | 1 | 100.0% | 0 | 0.0% | 1 |

Among the 257 respondents who showed awareness of warning signs or devices (Table 8), pedestrian gates appeared to have attracted their attention the most followed by “second train coming” electronic warning signs and flashing lights, as seen in Table 10. Other warning signs or devices did not appear to have left a lasting impression on respondents.

Table10. Q2a. Sign or Warning Devices Noticed

| Responses | Percent Respondents |
|--|---------------------|
| Detectable audible or visual warnings for people with disabilities | 13.5% |
| Fencing, swing gates, or zigzag | 12.8% |
| Flashing lights | 38.5% |
| Pedestrian crossing gate | 60.6%* |
| Pavement markings/change | 6.4% |
| Ringling bells | 26.0% |
| “Second train coming” electronic warning signs | 24.6%* |
| Other signs (see Q2a1 below) | 18.9% |
| Other (see Q2a2 below) | 7.7% |

*See discussion immediately below.

It is worth noting that the “second train coming” electronic warning sign was installed in only two of the crossing sites surveyed (Glen Ellyn and Villa Park crossings). Given that 61 surveys were completed at both sites, the actual percentage of respondents who noticed the particular warning sign would be 15 out of 61, or 25%. This is a relatively high percentage given

that these signs were activated considerably less frequently than other active signs and devices during the interview periods at both sites.

A similar observation can be made about awareness of the pedestrian gate in Table 10. Eight out of the 10 crossing sites surveyed had pedestrian gates installed. Given that we interviewed 244 respondents in those eight sites combined, the actual percentage of pedestrian gate awareness would be 148 out of 244, or 61%. In fact, pedestrian gates had the highest level of awareness of all warning signs and devices present among survey respondents.

Of the other warning signs noticed (not included in Table 10) the “look for trains” and the “do not stop on tracks” signs appeared to have attracted most of the attention with 25 and 15 mentions, respectively (Table 11). Other warning signs were even less conspicuous. For example, the sign warning about a \$500 fine received only six mentions. The “do not cross tracks” warning sign fared even worse after receiving just two mentions.

Table 11. Q2a1. Other Signs Noticed

| Frequently Cited Responses | Frequency |
|----------------------------|-----------|
| Look for trains | 25 |
| Do not stop on tracks | 15 |
| Warning of \$500 fine | 6 |
| Push to exit | 6 |
| RR signs | 4 |
| Do not cross tracks | 2 |
| Signs for cars | 1 |
| Total | 59 |

The warning signs and devices listed in Tables 10 and 11 were additionally categorized into two groups, active and passive, to further investigate visibility differences. Sixty-one percent of respondents noticed the active warning devices compared with 39% of the respondents who noticed the passive warning signs. This was virtually true independently of the mode of crossing. Interestingly, more users 31 years of age and older noticed the active warning devices, while more users 30 years of age and younger noticed the passive warning signs (Figure 14).

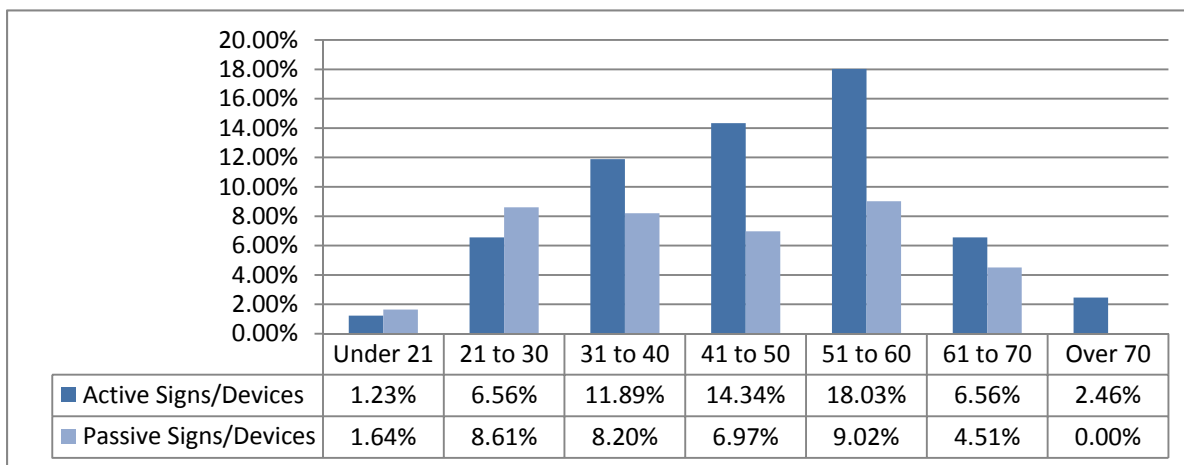


Figure 14. Active/passive signs/devices detection by age.

In addition, 62% of the male and 58% of the female respondents were more aware of active warning devices than passive warning signs. Finally, 60% of regular crossing users and 68% of respondents who rarely used a crossing noticed the active warning devices.

4.6.6 Q3. Attitudes About Safety at Crossing

A great majority of the respondents said they would not cross the tracks when the lights are flashing, the bells are ringing, or the gates are down (Table 12). However, 15% to 40% of the respondents would still cross the tracks against activated signals/warning devices.

Table 12. Q3. Attitudes about Safety at Crossing

| Responses | Would Cross | Percent | Would NOT Cross | Percent | Number of Respondents |
|---|-------------|---------|-----------------|---------|-----------------------|
| Cross tracks against signal if felt there was enough time | 68 | 21.8% | 244 | 78.2% | 312 |
| Cross tracks against signal if others were crossing | 49 | 15.7% | 263 | 84.3% | 312 |
| Cross tracks against signal if in a hurry | 60 | 19.2% | 252 | 80.8% | 312 |
| Cross tracks against signal if annoyed about having to wait | 12 | 3.8% | 300 | 96.1% | 312 |
| Cross tracks against signal if could not see a train coming | 125 | 40.1% | 187 | 59.9% | 312 |

Overall, female respondents in all age groups appeared to be more safety conscious than male respondents. Among male respondents, the youngest (under 21 years old) appeared to be the only group more likely to cross the tracks against activated signals/warning devices. Moreover, regular users appeared to be more safety conscious compared with irregular users.

4.6.7 Q4. Frequency of Seeing Others Cross Tracks

The majority of respondents (59%) have seen others crossing the tracks against activated signals/warning devices (Table 13). Regular users appeared to be much more emphatic in their responses. Moreover, female respondents seem more eager to spot such illegal activities.

Table 13. Q4. Frequency of Seeing Others Cross Tracks Against Signal

| Response | Frequency | Percent |
|--------------|-----------|---------|
| Never | 128 | 41.0% |
| Occasionally | 90 | 28.8% |
| Sometimes | 49 | 15.7% |
| Often | 27 | 8.7% |
| Always | 18 | 5.8% |
| Total | 312 | 100.0% |

4.6.8 Q5. Frequency of Crossing Tracks at Location Other Than Pedestrian Crossing

More than 90% of the users responded that they never cross the tracks at locations other than a pedestrian crossing (Table 14). Of those users, 87% were regular and 13% were irregular users. At various frequency levels, about 9% of the users (93% of whom were regular users) would cross the tracks at a location other than a crossing.

Table 14. Q5. Frequency of Crossing Tracks at Location Other than Pedestrian Crossing

| Response | Frequency | Percent |
|--------------|-----------|---------|
| Never | 285 | 91.3% |
| Occasionally | 13 | 4.2% |
| Sometimes | 10 | 3.2% |
| Often | 2 | 0.6% |
| Always | 2 | 0.6% |
| Total | 312 | 100.0% |

4.6.9 Q6. Other Crossing Locations

Twenty-seven users who did not respond “Never” in Question 5 were asked to state the alternative locations they use to cross the tracks. Four of those users crossed the tracks through emergency gates and eight through the road crossing. Seventeen users responded that they crossed the tracks at other locations (shown in Table 15).

Table 15. Q6. Other Crossing Locations

| Responses | Frequency |
|-----------------------------|-----------|
| In between crossings | 4 |
| Sometimes down the tracks | 3 |
| Crossing at the station | 2 |
| About a block up the tracks | 1 |
| About 20 feet away | 1 |
| About 50 feet away | 1 |
| About 100 feet north | 1 |
| Anywhere convenient | 1 |
| Other nearby street | 3 |
| Total | 17 |

4.6.10 Q7 Reasons for Crossing Tracks at Other Location

The 27 users who did not respond “Never” in Question 5 were also asked for some of the reasons behind crossing the tracks at a location other than the official pedestrian crossing. Twenty-five percent of the time, users claimed they were in a hurry (Table 16). In addition, 20% of the time, users felt they had enough time to get across safely.

Table 16. Q7. Reasons Might Cross Tracks at Other Location

| Responses | Frequency | Percent |
|---|-----------|---------|
| Felt had enough time to get across safely | 10 | 20.4% |
| The train was stopped | 6 | 12.2% |
| Other people were crossing | 2 | 4.1% |
| I could not see a train coming | 8 | 16.3% |
| I previously crossed when a train was coming and was not hurt | 2 | 4.1% |
| I was in a hurry | 12 | 24.5% |
| Other (see Q7_7 below) | 9 | 18.4% |
| Total* | 49 | 100.0% |

*The total number of mentions may exceed/be less than the total number of respondents.

Some of the users provided more specific information, as shown in Table 17.

Table 17. Q7_7. Other Reasons Might Cross Tracks at Other Location

| Frequently Cited Responses | Frequency |
|-----------------------------------|-----------|
| Shortcut | 2 |
| 65th Street/closer to destination | 2 |
| Know exactly how much time has | 1 |
| Was gonna miss train | 1 |
| Find quarters along the tracks | 1 |
| Emergency | 1 |
| Where I have to catch the train | 1 |
| Total | 9 |

4.6.11 Q8. Legality of Crossing Tracks Against Activated Signal

The great majority of the respondents recognize that it is illegal to cross the tracks against activated signals (Table 18). However, 10% of the respondents (90% of whom had at least some college education) believe that it is legal to do so (naturally, this is worrisome).

Table 18. Q8. Legality of Crossing Tracks against Signal

| Responses | Frequency | Percent Valid Responses |
|--------------------|-----------|-------------------------|
| Legal | 32 | 10.3% |
| Illegal | 278 | 89.7% |
| Don't know | 1 | — |
| Refused or missing | 1 | — |
| Total | 312 | 100.0% |

The distribution of the two groups by age is shown in Figure 15. Generally speaking, perceptions of illegality when crossing against activated signals/devices increase with age.

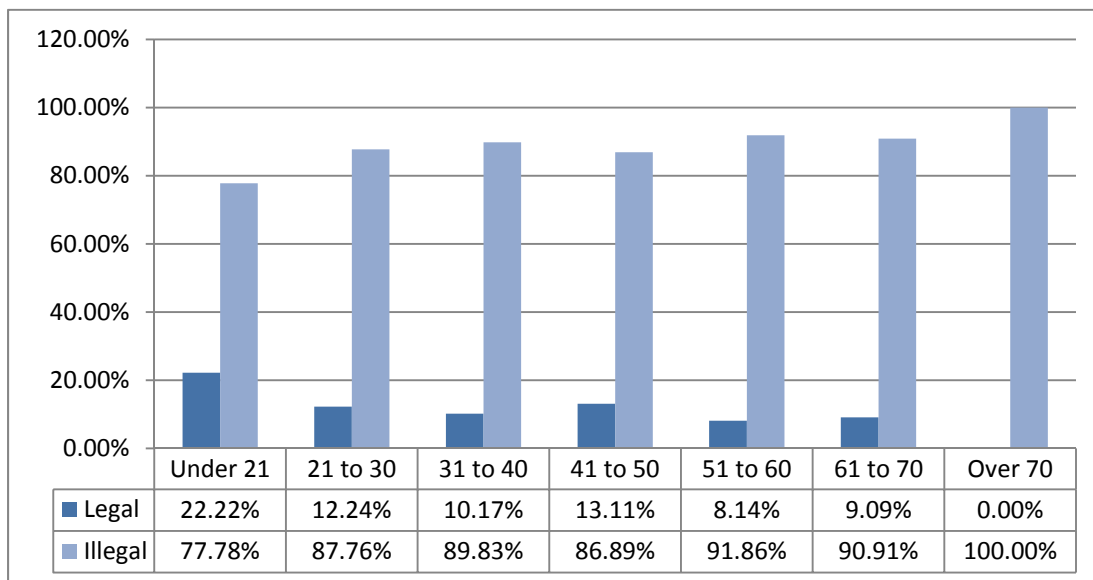


Figure 15. Legality of crossing tracks against activate signals by age.

There is a difference in the perception of legality between regular and irregular users (Figure 16). Thirty percent of irregular users compared with only seven percent of regular users believe it is legal to cross the tracks when the signals/devices are activated.

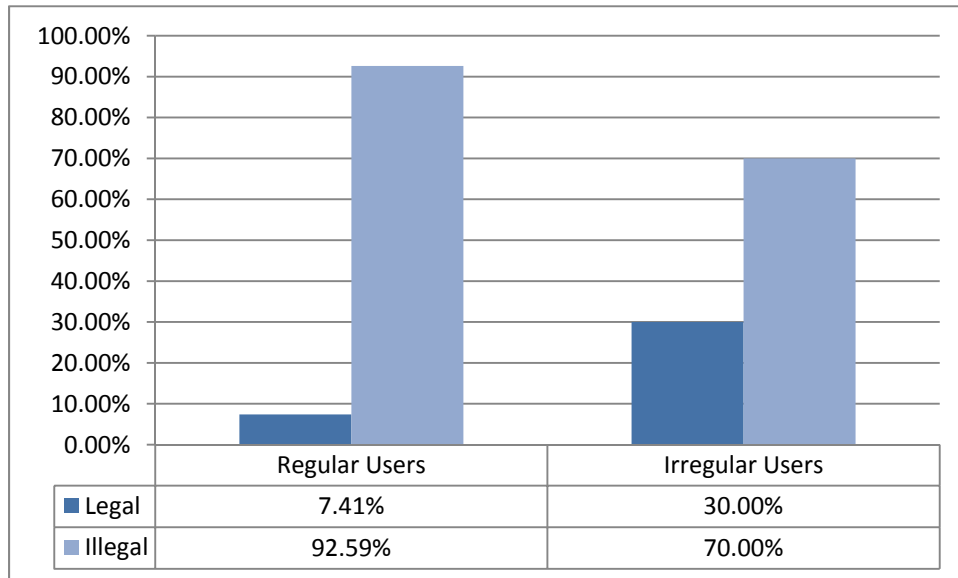


Figure 16. Perceptions of legality of crossing tracks between regular/irregular users.

Similar perception differences appear between users who noticed signs/warning devices at a crossing and those who did not. Twenty percent of respondents who were not as aware of safety devices at a crossing believe it is legal to cross against activated safety devices, while only eight percent of the attentive users believe it is legal to do so.

Moreover, respondents' own perceptions about legally/illegally crossing against activated safety devices affect their awareness of the crossing behavior of other users. For example, 82% of respondents who believe it is illegal to cross against activated safety signals/devices have never seen other pedestrians doing so (Figure 17). Overall, the more likely a user perceives it is illegal to cross against activated safety signals/devices, the more frequently he/she will observe others doing so.

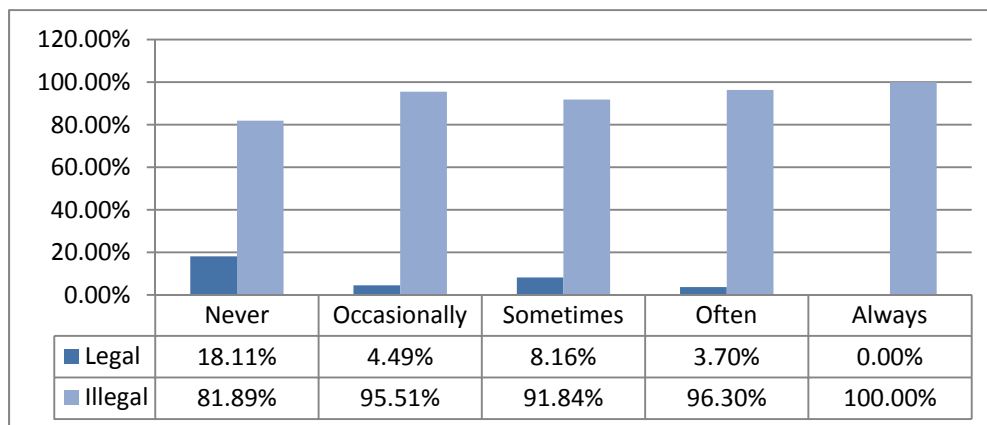


Figure 17. Perceptions of legality and level of general awareness.

4.6.12 Q9. Perception of Safety Using Pedestrian Crossing

Four in five users felt very safe or extremely safe using a pedestrian crossing (Table 19). Less than five percent of the users felt slightly safe or not at all safe doing so. Such perceptions are evenly shared between male and female respondents, as well as regular and irregular users. Moreover, 98% of the respondents who felt very safe or extremely safe were over 70 years old.

Table 19. Q9. Safety Using Pedestrian Crossing

| Responses | Frequency | Percent |
|-----------------|-----------|---------|
| Extremely safe | 110 | 35.3% |
| Very safe | 139 | 44.6% |
| Moderately safe | 49 | 15.7% |
| Slightly safe | 9 | 2.9% |
| Not at all safe | 5 | 1.6% |
| Total | 312 | 100.0% |

4.6.13 Q10. Difficulty Crossing Tracks

Eighty-five percent of the respondents felt that they had no difficulty crossing the tracks, while remaining 15% found some level of difficulty in doing so (Table 20). There was little variability in attitudes among age and gender groups, as well as between regular and irregular users.

Table 20. Q10. Difficulty Crossing Tracks

| Responses | Frequency | Percent Valid Responses |
|----------------------|-----------|-------------------------|
| Extremely difficult | 1 | 0.3% |
| Moderately difficult | 16 | 5.2% |
| Slightly difficult | 30 | 9.7% |
| Not at all difficult | 263 | 84.8% |
| Refused or missing | 2 | — |
| Total | 312 | 100.0% |

There appears to be a relationship between the perception of safety and the level of difficulty using a crossing. The safer a user perceives using the crossing, the less likely it is he/she would find it difficult to do so.

4.6.14 Q11. Reasons Crossing Tracks Is Difficult

The 47 respondents who found some difficulty crossing the tracks (Table 20) were subsequently asked to explain the reasons for their difficulty. More than 90% of the answers were given by respondents with at least a high school education. The difficulty with the surface of the path/sidewalk when in disrepair was mentioned as such a reason 14% of the time (Table 21). Other notable mentions include the following:

- “Audible (safety) devices are not loud enough.” (We were unable to verify the sound level of electronic crossing bells; neither were we able to identify a maximum sound level regulated by the FRA or any other state.)
- “Signs are not reflective at night.” (Note that standard signs on the warning devices themselves are MUTCD type regulatory or warning signs. However, there are many other types of signs that are used to provide warnings to motorists and non-motorists that are not MUTCD compliant. The 2009 edition of the MUTCD does require specific levels of retroreflectivity for MUTCD approved signs.)

Table 21. Q11. Reasons Crossing Tracks Is Difficult

| Responses | Frequency | Percent |
|--|-----------|---------|
| Visual pollution/can't see signs | 2 | 3.1% |
| Signs are not reflective at night | 4 | 6.3% |
| Audible devices are not loud enough | 5 | 7.8% |
| The direction of the path/sidewalk is not clear | 1 | 1.6% |
| The surface of the path/sidewalk is in disrepair | 9 | 14.1% |
| The line of sight to view an approaching train is obstructed | 1 | 1.6% |
| The second-train warning sign has a glare/is difficult to read | 1 | 1.6% |
| Other (see Q11_8 below) | 41 | 64.1% |
| Total* | 64 | 100.0% |

*The total number of mentions may exceed/be less than the total number of respondents.

Of the five mentions that the audible warning devices (bells) were not loud enough, three were expressed by respondents at the La Grange crossing and two at the Riverside crossing. Of the 47 respondents, four walkers were listening to music on their earphones or talking on their cell phone. All four expressed some difficulty crossing the tracks for reasons shown in Table 21. One of the four respondents commented on the condition of the sidewalk surface.

Respondents also provided other reasons that make it difficult to safely cross the tracks. These responses are shown in Table 22.

Table 22. Q11_8. Other Reasons Crossing Tracks Is Difficult

| Frequently Cited Responses | Frequency |
|---|-----------|
| Slippery surface | 7 |
| Car traffic too close | 6 |
| Bumpy/rough terrain for bicycles, strollers, etc. | 5 |
| Not enough time to cross | 2 |
| Kids are reckless | 2 |
| Have to wait too long when 2nd train passes | 2 |
| Cars go very fast/speed | 2 |
| Gates, deterrent from crossing | 2 |
| Too many cars/traffic | 2 |
| Distractions/busy intersection | 1 |
| Gut feeling | 1 |
| History of problems | 1 |
| I have no idea | 1 |
| Cars don't yield | 1 |
| Bad weather | 1 |
| Have to walk too far to cross | 1 |
| Incline | 1 |
| Curve, 3 tracks | 1 |
| Car traffic blind/light patterns cause congestion | 1 |
| Not wide-enough sidewalk | 1 |
| Too many trains crossing at once | 1 |
| Total | 42 |

4.6.15 Q12. Additions to Improve Safety at Crossing

All 312 survey participants were asked to offer suggestions for improving safety at the pedestrian crossing they were using. There were no suggestions made almost half of the time (Table 23). Ninety percent of the suggestions were made by respondents with at least a high school

level of education. The rest of the respondents offered a number of suggestions, as shown in Table 23.

Table 23. Q12. Additions to Improve Safety at Crossing

| Responses | Frequency | Percent |
|--|------------------|----------------|
| Detectable audible or visual warnings for people with disabilities | 5 | 1.5% |
| Fencing, swing gates, or zigzag | 6 | 1.8% |
| Flashing lights | 10 | 2.9% |
| Pedestrian crossing gate(s) | 18 | 5.3% |
| Pavement markings/change | 14 | 4.1% |
| Ringling bells | 5 | 1.5% |
| "Second train coming" electronic warning signs | 4 | 1.2% |
| Other signs (see Q12_8 below) | 17 | 5.0% |
| Other (see Q12_9 below) | 93 | 27.3% |
| Nothing/no improvements needed | 169 | 49.6% |
| Total* | 341 | 100.0% |

*The total number of mentions may exceed the total number of respondents.

Table 24 shows the suggestions made regarding sign additions to improve safety at the crossing. None of these suggestions are specific enough to stand out.

Table 24. Q12_8. Sign Additions to Improve Safety at Crossing

| Frequently Cited Responses | Frequency |
|--|------------------|
| Signs for pedestrians | 7 |
| Bold letters and bright colors | 2 |
| No crossing when lights are flashing/Illegal | 2 |
| Illegal to cross/inform public of law/ \$500 fine sign | 2 |
| Don't cross when gates are down | 1 |
| Block off crossing | 1 |
| Stop as soon as you hear bells | 1 |
| Look both ways, RR (both sides of crossing) | 1 |
| Railroad crossing, caution train | 1 |
| Do not stop on tracks | 1 |

Finally, Table 25 shows other suggestions to improve overall safety at the pedestrian crossing used by the respondents. Suggestions such as police enforcement or a crossing guard, as well as about grade separation, clearly stand out.

Table 25. Q12_9. Other Additions to Improve Safety at Crossing

| Frequently Cited Responses | Frequency |
|--|-----------|
| Police enforcement/crossing guard | 16 |
| Pedestrian bridge/underpass | 15 |
| Sidewalk barrier/fence | 6 |
| Open pathway | 6 |
| Additional crossings | 5 |
| Better gates for cars and pedestrians | 4 |
| Slow down cars/traffic | 4 |
| Slippery when wet | 4 |
| Warnings could be sooner | 3 |
| Replace rubber crossing surface/smooth surface | 3 |
| Maintenance | 3 |
| Educate people/just need to pay attention | 3 |
| Separation from cars for pedestrians/camera monitoring | 2 |
| Wider sidewalk | 2 |
| Walk way to close | 1 |
| Cater to disabled/wheelchair | 1 |
| Change location of pedestrian gates | 1 |
| Viaduct construction | 1 |
| Camera lights prevent cars from going around gate | 1 |
| Larger lights | 1 |
| Flaggers | 1 |
| Standing path for pedestrians to wait | 1 |
| Lights on floor | 1 |
| Plant flowers to make scenery nice | 1 |
| Trim tree on north side to clear vision | 1 |
| Bigger signs/more visibility | 1 |

4.6.16 Q13. Disability Status

Eight percent of the respondents (85% of who were at least high school graduates) said they had some kind of disability (Table 26). This is very close to an average of 8% for the northeastern Illinois region, based on 2008–2010 estimates from the American Community Survey (ACS) (<http://www.census.gov/acs/www>).

Table 26. Q13. Disability Status

| Responses | Frequency | Percent Valid Responses |
|-----------------------|-----------|-------------------------|
| Yes (see Q13_1 below) | 26 | 8.4% |
| No | 285 | 91.6% |
| Refused or missing | 1 | — |
| Total | 312 | 100.0% |

Survey participants were asked to describe specific disability they have. These are shown in Table 27, by location. The crossing at 119th Street appears to be the focus of 7 out of the total 25 specific disabilities cited. Of the other locations, the crossing in Deerfield had 3 respondents, all older than age 50, who said they had hearing difficulties.

Table 27. Q13_1. Reporting Any Kind of Disability

| US DOT Inventory No. | Location | Specific Disabilities Cited | | | | | | | | | | |
|----------------------|-------------------------------------|-----------------------------|--------------|-----------------|--------------------------|--------------------|--------------------|--------------------------------|----------|----------------|---------|------------------|
| | | Visual | Hearing Loss | Physical (Back) | Walk with Cane/Arthritis | Leg Problem (Limp) | Hearing and Visual | Spinal Cord Stimulator in Back | Diabetes | Cerebral Palsy | Amputee | Knee Replacement |
| 608830M | Chicago(119th St) | 2 | 1 | 1 | | | 1 | | | 1 | 1 | |
| 079493L | Riverside (ILL43/Harlem Ave) | | | | 1 | | | | | 1 | | |
| 173887G | Chicago (Nagle Ave) | | | | | | | 1 | | | | 1 |
| 079508Y | La Grange (US12/ La Grange Rd) | | | | | | | | | | | |
| 174948Y | Glen Ellyn (Park Blvd) | | | | | 2 | | | | | | |
| 843811C | Chicago(Marquette Rd) | 1 | | | | | | | | | | |
| 388040W | Deerfield (Osterman Ave) | 1 | 3 | | | | 1 | | | | | |
| 079521M | Hinsdale (Ped/Park St) | 1 | | | | | | | | | | |
| 174937L | Villa Park (Ped/Villa Park Depot) | 1 | | 1 | | | | | | | | |
| 372128W | Elmwood Park (Ped/Elmwood Pk Depot) | 1 | 1 | | 1 | | | | | | | |

About half of the respondents with a specific type of disability offered suggestions for improvements or specifically identified problems that made crossings seem more difficult or riskier to use:

- Nagle Avenue crossing: A respondent with a spinal cord stimulator would like to see more attention paid toward kids/teens crossing the tracks. A respondent with a knee replacement would like to have a traffic barrier installed.
- 119th Street crossing: A respondent with visual difficulties would like longer advanced warnings for trains. A respondent with cerebral palsy lamented the absence of a dedicated pedestrian pathway. Yet another respondent, a leg amputee, would like to have flaggers present at the crossing.
- Elmwood Park crossing: A respondent walking with the assistance of a cane because of arthritic knees would like to have the rubber crossing surface replaced. A respondent with hearing problems would like to have a smoother crossing surface.
- Glen Ellyn crossing: A respondent with a right leg limp from an accident would like a gate modification so that people cannot go under it. A respondent with a serious leg

problem (limping) would like the addition of a crossing near the middle of the train station.

- Riverside crossing: A respondent suffering from diabetes would like to see greater presence of law enforcement.
- Villa Park crossing: A respondent with chronic back pain would like to have flowers planted to improve the scenery.
- Deerfield crossing: A respondent with auditory problems would like to have a crossing guard present. A respondent with visual problems would like to have the public informed that it is illegal to cross when lights are flashing in addition to having a \$500 fine sign installed.

4.6.17 Q14. Respondents Age

The age distribution of the survey participants is shown in Table 28.

Table 28. Q14. Respondent Age

| Responses | Frequency | Percent Valid Responses |
|---|-----------|-------------------------|
| Under 21 | 9 | 2.9% |
| 21 to 30 | 49 | 16.0% |
| 31 to 40 | 61 | 19.9% |
| 41 to 50 | 61 | 19.9% |
| 51 to 60 | 86 | 28.0% |
| 61 to 70 | 33 | 10.7% |
| Over 70 | 8 | 2.6% |
| No coded response applicable (see Q 14_1 below) | 2 | — |
| Refused or missing (see Q 14_1 below) | 3 | — |
| Total | 312 | 100.0% |

Table 29 shows two cases with unspecified age information.

Table 29. Q14_1. Unspecified Respondents Age

| Responses | Frequency |
|---------------------------------------|-----------|
| Before 1960 | 1 |
| Refused to answer, but said "over 60" | 1 |

4.6.18 Q15. Highest Grade or Level of Education Completed

The highest level of education attained by survey participants is shown in Table 30.

Table 30. Q15. Highest Grade or Level of Education Completed

| Responses | Frequency | Percent Valid Responses |
|----------------------------------|-----------|-------------------------|
| 8th grade or less | 5 | 1.6% |
| Some high school | 19 | 6.1% |
| High school graduate/GED | 70 | 22.7% |
| Some college | 76 | 24.6% |
| College or other advanced degree | 139 | 45.0% |
| Refused or missing | 3 | — |
| Total | 312 | 100.0% |

4.7 REGRESSION ANALYSIS

The discussion about user attitudes while crossing pedestrian-rail grade crossings revealed associations of attributes related to particular behaviors. This section describes the nature of these associations and the variations of user attitudes using regression analysis. In particular, we investigated how the propensity to be in violation of activated devices and signs is related to user-specific and crossing-specific attributes. It should be noted that the term “violation” refers to a trespassing violation of the Illinois Vehicle Code (P.A. 96-1244, Section 11-1011) discussed in more detail in Chapter 5. The data sources for this analysis were information from the ICC crossing inventory, the user survey, site visits, and video data collection.

Overall, the average (unconditional) propensity for trespassing violation at all crossings was 47.7%. It ranged from 19.4% in La Grange to 78.4% at 119th Street. To examine the conditional effect of various factors on the propensity for trespassing, we estimated numerous logistic regressions. Among the dozens of candidate models analyzed, the model below stood out as a satisfactory trade-off between statistical fit and parameter parsimony. The model is given by the equation:

$$\text{logit}(p_i) = \log\left(\frac{p_i}{1 - p_i}\right) = b_o + b_1x_{i1} + b_2x_{i2} + \dots + b_kx_{ik}$$

where p_i is the probability that individual i has the propensity to be in violation conditional on the independent variables, x_{ik} . The dependent variable in this logistic regression (Cox and Snell 1989; Hosmer and Lemeshow 1989; Agresti 1990; Collett 1991) is the *logit* or *log-odds* that individual i exhibited a propensity of being in violation against activated warning devices or signs while crossing the tracks. The information was obtained from responses to Question 3 in the survey (Table 12). In particular, pedestrians who stated they would cross the tracks if they felt there was enough time, if others were crossing, if they were in a hurry, if they were annoyed by having to wait, if they could not see a train coming were thought to have displayed the propensity of being in violation. In this regard, of the 312 users surveyed, 146 displayed and 160 did not display such a propensity. The responses from the remaining six users were not used because of missing information.

It would be worth noting that, although user interviews and video monitoring occurred in parallel at each crossing, none of the respondents were among the 13.7% observed in the video of being in violation. Clearly, the video observations at each crossing were a 1-day event, while the respondents in the user survey expressed general attitudes. However, at crossings with high-pedestrian-violation rates per gate activation, there is a higher chance that pedestrians naturally would have a higher propensity to violate activated devices or signs for the reasons mentioned in Question 3 of the survey (Table 12).

The explanatory variables included in the final model (Table 31) and the sources of information were as follows:

- Gender: The respondent’s gender—from the user survey (0: female; 1: male)
- Pedestrian gate: The number of pedestrian gates deployed at each of the 10 crossings—from the ICC crossing inventory as confirmed by site visits
- Trains: The number of daily trains at each of the 10 crossings—from the ICC/FRA inventory

The model estimation results are shown in Table 31. When the explanatory variables in a logistic regression are relatively small in number and are both qualitative and quantitative, the sample size requirements for goodness-of-fit tests are not met. An alternative strategy for testing goodness of fit in this case is to examine the residual score statistic. This criterion is based on the relationship of the residuals of the model with other potential explanatory variables. If an association exists, then the additional explanatory variable should also be included in the model. This test is distributed as chi-square, with degrees of freedom equal to

the difference in the number of parameters in the original model and the number of parameters in the expanded model. In this case, the value of the statistic is 7.91 and the p-value is 0.24, the main effects model fits adequately, and no additional interactions must be added.

Table 31. Logistic Regression Estimation Results

| Parameter | DF | Estimate | Standard Error | Wald Chi-Square | Pr > Chi-Sq | Odds Ratio (95% Wald Confidence Limits) |
|-----------------|----|----------|----------------|-----------------|-------------|---|
| Intercept | 1 | 1.2059 | 0.3409 | 12.5109 | 0.0004 | |
| Gender (Female) | 1 | -0.5536 | 0.2396 | 5.3385 | 0.0209 | 0.575 (0.359, 0.919) |
| Pedestrian Gate | 1 | -0.1518 | 0.0663 | 5.2380 | 0.0221 | 0.859 (0.754, 0.978) |
| Trains | 1 | -0.00723 | 0.00255 | 8.0219 | 0.0046 | 0.993 (0.988, 0.998) |

The coefficient of gender is -0.5536 , and its standard error is 0.2396 . The p-value for the Wald chi-square test is 0.0209 , indicating a significant (at the 0.05 level) association between the propensity to be in violation and gender. The estimated odds ratio (female vs. male), adjusted for other explanatory variables, is 0.575 (95% CI: $0.36-0.92$). This means that the predicted odds for violation propensity were about 42% for female respondents. On a probability scale, female respondents (compared with male respondents) were, on average, 37% as likely to be in violation.

Similarly, the estimated odds ratio for pedestrian gates is 0.859 (95% CI $0.75-0.98$) implying that each additional pedestrian gate is associated with 14% decrease in the predicted odds of the propensity to be in violation. On a probability scale, respondents at crossings equipped with one pedestrian gate were, on average, 46% as likely to be involved in a trespassing violation (when compared with respondents at crossings with no pedestrian gates).

Because pedestrian gates are usually installed in tandem (for dedicated pedestrian crossings) or in fours (on adjacent sidewalks leading to the tracks), the decrease in the odds can be 26% and 45%, respectively. On a probability scale, respondents at crossings equipped with two (four) pedestrian gates were, on average, 42% (35%) as likely to commit a trespassing violation. This finding about pedestrian gates, if corroborated in larger studies, may have the following implications:

- It may have an impact on collision reduction at grade crossings because crossings with a high number of collisions also have a high level of violation rates (see discussion on video data analysis in Chapter 5).
- It may help alleviate the concerns of railroads about the effectiveness of pedestrian gates (as discussed in Chapter 1).

Finally, with every additional train in daily traffic, there is a less than a 1% decrease in the odds of committing a trespassing violation. The decrease in odds for an additional 5 (10) trains is 4% (7%). There were not enough samples at the crossing level to estimate the additional effects of individual crossings.

4.8 VIOLATION PROPENSITY, CROSSING LOCATION, AND TYPE OF RAILROAD OPERATIONS

We sought to investigate the association between violation propensity and various individual crossing characteristics using categorical data analysis techniques. The small sample size did not permit development of more complicated regression models.

First, we classified the crossing locations into two groups, a city group that included study crossings within the City of Chicago, and a suburban group that included the rest of the crossings. The highly significant value ($Q = 22.3$, $p < 0.0001$, with 1 degree of freedom) of the Pearson chi-square statistic (Agresti 2007) implies that there is a strong association between crossing location and violation propensity such that city crossings result in increased violation propensity compared with suburban crossings. In particular, the city crossings resulted in a 67%, and the suburban crossings resulted in 38% violation propensity among the survey respondents.

To identify an association between railroad type and violation propensity, we classified the operating railroads into freight only, passenger only, and passenger and freight, implicitly ranking the crossings from low to high to very high daily train traffic. Using the Cochran-Mantel-Haenszel statistic Q_{CSMH} (Agresti 2007), we found ($Q_{CSMH} = 8.6$, $p < 0.01$, with 1 degree of freedom) a significant association between type of railroad operations and violation propensity. More specifically, 78% of respondents at crossings experiencing passenger-only operations, 42% in passenger and freight operations, and 56% in freight-only operations admitted a violation propensity. There were not enough samples to examine the additional effect of the crossing location.

4.9 CONCLUSIONS

Within the survey scope limitations and to the extent that observations from the analysis of the users survey can be generalized, several findings merit attention because they may have implications about the design and placement of signs and warning systems at pedestrian-rail grade crossings.

- Certain activities, such as talking on a cell phone, pushing a stroller, or listening to music on earphones, may interfere with environmental awareness while traveling across a grade crossing. In addition, such awareness appears to diminish with age.
- Active signs at grade crossings are noticed more frequently than passive signs, independent of gender or frequency of using the crossing. Moreover, younger users are more likely to pay attention to active signs, while older users notice passive signs more frequently.
- Being a regular user at pedestrian-rail grade crossings appears to help with awareness of signs and warning devices. Moreover, regular users appear to be more safety conscious compared with irregular users.
- Overall, female respondents in all age groups appear to be more safety conscious than male respondents when using a crossing. In addition, young males (under 21 years old) appear to be the only group in this sample more likely to cross the tracks against activated signals/warning devices.
- Trespassing by crossing the tracks at locations other than a pedestrian crossing is still a habit of a small minority of users that merits attention.
- Safety improvements at pedestrian grade crossings should always consider the special needs of people with disabilities, who constitute a sizable minority of users.
- More intensified educational and enforcement campaigns may be necessary to convince all pedestrian users that (1) it is illegal to cross against activated signals/devices and (2) crossing the tracks at locations other than a pedestrian crossing constitutes trespassing.
- The propensity of respondents to be in violation of activated devices and signs while crossing the tracks seems to decrease when rail grade crossings are equipped with pedestrian gates.
- The violation propensity among respondents is relatively increased at city rail grade crossings vis-à-vis suburban rail grade crossings.

- Survey respondents admitted a higher violation propensity in rail grade crossings with passenger-only operations, followed by crossings with freight-only operations, and, lastly, by crossings with passenger and freight operations.

CHAPTER 5 VIDEO ANALYSIS OF PEDESTRIAN BEHAVIOR

5.1 INTRODUCTION

Concurrently with the survey activities of non-motorized users as discussed in Chapter 4, we conducted video monitoring of pedestrian and train traffic at those crossings. The objectives of this activity were to (1) develop an overall understanding about factors affecting pedestrian crossing behavior, in addition to the ones found from the survey; and (2) corroborate findings from the survey that could not be generalized because of sampling limitations. In particular, the following aspects of the crossing environment were evaluated: (1) the effect of crossing characteristics on pedestrian behavior, (2) compliance by pedestrians with existing control equipment, and (3) variations in pedestrian volumes and their impact on crossing behavior.

Tracking pedestrian movement at crossings is a time-consuming activity that can be assisted by computerized techniques (Prassler et al. 1999; Lam et al. 2002; Sheikh et al. 2004). In this study, resource allocation constraints during field work did not allow us to fully automate data collection and processing. A realized benefit in using “trained eyes” to assist the data processing was that it allowed us to customize the collection of information with attributes unlikely to have been discerned by existing computer algorithms. A list of such attributes in the developed database is shown in Appendix I. While in some cases, information retrieval remained unattainable, the list in Appendix I shows the variety of information that is possible to obtain in a typical video data collection. The type of information that could be obtained with additional resources in observational studies of rail grade crossings is documented elsewhere (Sposato et al. 2006).

5.2 VIDEO DATA COLLECTION

The video data collection occurred in October and November 2011. At each crossing, we used one scout camera to capture all approaches to each crossing. The camera was small enough to fit in a car and be deployed by one person in less than 10 minutes. Scheduling arrangements were made so that the camera and tripod equipment could be set up at each successive crossing in a speedy manner. As a result, it was possible to record video data from 12:00:00 midnight to 11:45:00 p.m. and cover the 10 study crossings in 10 full days.

The camera was mounted on a tripod and secured on grass surfaces with metal ground spikes. Criteria for a suitable camera location included the potential to capture higher pedestrian activity and likely directional flow patterns of pedestrians. Equipment pictures and specifications can be seen in Appendix G of this report.

The approximate location of the video equipment at each crossing is shown in Appendix H of this report. In these exhibits, the crossing ID is shown at the center of each picture next to the yellow pushpin. The approximate location for camera placement is indicated with a red box when the camera was mounted on a tripod. Sites where the camera could have been mounted on a traffic signal pole or light utility pole are designated by TS and LP, respectively. Each camera location was cautiously selected to ensure that it did not interfere with railroad operations and maintenance or with vehicular and pedestrian traffic. The final location of the camera at each crossing was coordinated with the respective operating railroad agency, municipality, and IDOT.

Staff from MultiModes Engineering (<http://www.multimodesengineering.com/>), a study subconsultant, installed and secured the camera equipment from site to site. Upon completing the video monitoring activities at each crossing, the video shot at each crossing was uploaded to a website provided by Miovision Inc. (<http://www.miovision.com/>), the company from which the video equipment was rented. The video was subsequently converted from a proprietary format to an MPEG-4 (MP4) and Waveform Audio File (WAV) file format for further analysis.

The total cost for the video monitoring activities was \$8,530. During the entire period of video monitoring, we observed 396 gate activations. As a result, the average cost per gate activation was \$21.54. The average cost per gate activation and per hour of video monitoring (as a way to control for equipment malfunction at the Harlem Avenue crossing, as discussed later) for each site can also be seen in Table 32.

Table 32. Average Cost of Video Data Collection

| Crossing Location | Average Cost per Gate Activation | Average Cost per Gate Activation and Hour of Video Monitoring | Average Cost per Pedestrian Counted |
|--|---|--|--|
| US12/La Grange Rd in LaGrange | \$8.45 | \$0.36 | \$0.35 |
| IL43/Harlem Ave in Riverside | \$13.54 | \$0.92 | \$1.43 |
| Ped/Villa Park Depot in Villa Park | \$17.41 | \$0.73 | \$0.84 |
| Ped/Elmwood Park Depot in Elmwood Park | \$18.54 | \$0.78 | \$1.61 |
| Park Blvd in Glen Ellyn | \$19.84 | \$0.84 | \$0.74 |
| 119th St in Chicago | \$34.12 | \$1.44 | \$2.44 |
| Marquette Rd in Chicago | \$37.09 | \$1.56 | \$1.67 |
| Osterman Ave in Deerfield | \$44.89 | \$1.89 | \$4.90 |
| Nagle Ave in Chicago | \$47.39 | \$2.00 | \$1.09 |
| Ped/Park St Hinsdale | \$94.78 | \$3.99 | \$16.73 |

Upon receiving the video files, the study's principal investigators supervised graduate research assistants associated with the study in conducting multiple viewings of the data and organizing the information in a database. Database development accomplished the following objectives:

- Database attributes (shown in Appendix I) were populated as possible and were used as primary data in the analysis reported below.
- Secondary (derivative) data were developed using information from the primary data and were also used in the analysis (e.g., number of gate activations, violation rates per gate activation).
- Additional derivative data can be developed using primary data information for future analyses.
- The database Comments field included time-stamped information about the train, track, and crossing environment, such as the presence of a car; whether a violation (Type I, II, or III) was committed by a pedestrian while getting off a train; unusual pedestrian behavior (e.g., hanging around track area, periodically crouching down, touching track); whether a train, while stopped, blocked the crossing; false alarm gate activation; second-train or multiple-train events, gate activation/deactivation failure and follow-up by railroad personnel; pedestrian trespassing violations away from crossing; reduced train speed affecting the time between gate activation and train arrival; train cars having difficulty clearing a crossing because of vehicular traffic; track maintenance activities; and whether it was raining and, if so, the amount of visibility
- The database Comments field also included time-stamped information about particular pedestrian behaviors, such as whether the pedestrian ran to cross the tracks or ran to catch a train, got off a train, or walked slowly; whether the pedestrian looked both ways; whether the non-motorized user was a cyclist, was pushing a

stroller, was walking a bicycle, was walking a dog, or was pulling children in a wagon; whether the pedestrian was a student or a commuter; whether the pedestrian was using a wheelchair, riding a skateboard, or using rollerblades; whether a pedestrian was waiting inside a pedestrian gate or walking along the tracks; and whether the pedestrian used the highway crossing instead of the sidewalk.

5.3 ANALYSIS OF PEDESTRIAN VIOLATIONS

The Illinois Vehicle Code (1996; 625 ILCS 5/11-1011) mandates that

- No pedestrian shall pass through, around, over, or under any crossing gate or barrier at a railroad grade crossing or bridge while such gate or barrier is closed or is being opened or closed.
- No pedestrian shall enter, remain upon or traverse over a railroad grade crossing or pedestrian walkway crossing a railroad track when an audible bell or clearly visible electric or mechanical signal device is operational giving warning of the presence, approach, passage, or departure of a railroad train or railroad track equipment.
- A violation of any part of this Section is a petty offense for which a \$250 fine shall be imposed for a first violation, and a \$500 fine shall be imposed for a second or subsequent violation. The court may impose 25 hours of community service in place of the \$250 fine for a first violation.

Similar statutes are in effect in most other states, although a complete inventory of existing legislation was outside the scope of the study. The primary objective of such policies is to provide a deterrent to risky pedestrian behavior at rail grade crossings.

It was evident from the video observations that the majority of pedestrians were not compliant with existing law (Table 33; in the context of this analysis the term “violation” is used to signify a violation of the Illinois Vehicle Code). Indeed, during gate activations at all 10 crossings, 1,780 pedestrians were observed crossing the tracks. Of those, 1,021 (57%) committed a Type I, II, or III violation (defined below), while the remaining 759 (43%) did not commit any of the three violation types. The remaining 5,844 of the total 7,624 users crossed the tracks when the gates were not activated. Percentagewise, the Hinsdale crossing was at the low end with 27% (3 out of 11) of pedestrians having committed a violation. At the high end, 92% (54 out of 59) of pedestrians committed a violation at the 119th Street crossing. A discussion about the variation of violation level among crossings is provided later in this chapter.

Table 33. Number of Pedestrians by Violation Type and Gate Activation State

| US DOT Inventory No. | County Name | City Name | Street Name | Number of Pedestrians by Violation Type (I, II, III, NA) and Gate Activation State (Y, N) | | | | | | | |
|----------------------|-------------|-----------|-------------------|---|-----|-----|------|-----|------|-----|-------|
| | | | | I | II | III | NA | | All | | Total |
| | | | | | | | N | Y | N | Y | |
| 608830M | Cook | Chicago | 119th St | 1 | 10 | 43 | 291 | 5 | 291 | 59 | 350 |
| 079493L | Cook | Riverside | ILL43/Harlem Ave | 0 | 125 | 8 | 422 | 43 | 422 | 176 | 598 |
| 173887G | Cook | Chicago | Nagle Ave | 15 | 15 | 3 | 673 | 75 | 673 | 108 | 781 |
| 079508Y | Cook | La Grange | US12/La Grange Rd | 15 | 397 | 34 | 1757 | 248 | 1757 | 694 | 2451 |

Table continues, next page

| US DOT Inventory No. | County Name | City Name | Street Name | Number of Pedestrians by Violation Type (I, II, III, NA) and Gate Activation State (Y, N) | | | | | | | |
|----------------------|-------------|--------------|------------------------|---|-----|-----|------|-----|------|------|-------|
| | | | | I | II | III | NA | | All | | Total |
| | | | | | | | N | Y | N | Y | |
| 174948Y | DuPage | Glen Ellyn | Park Blvd | 2 | 99 | 15 | 918 | 125 | 918 | 241 | 1159 |
| 843811C | Cook | Chicago | Marquette Rd | 0 | 30 | 2 | 453 | 27 | 453 | 59 | 512 |
| 388040W | Lake | Deerfield | Osterman Ave | 0 | 8 | 0 | 149 | 17 | 149 | 25 | 174 |
| 079521M | DuPage | Hinsdale | Ped/Park St* | 0 | 0 | 3 | 40 | 8 | 40 | 11 | 51 |
| 174937L | DuPage | Villa Park | Ped/Villa Park Depot | 2 | 104 | 4 | 736 | 172 | 736 | 282 | 1018 |
| 372128W | Cook | Elmwood Park | Ped/Elmwood Park Depot | 4 | 50 | 32 | 405 | 39 | 405 | 125 | 530 |
| Total | | | | 39 | 838 | 144 | 5844 | 759 | 5844 | 1780 | 7624 |

*Dedicated pedestrian crossing.

The percentage of users observed to be in violation (57%) appears to be higher than the 15% to 40% who admitted that, on occasion, they would have been in violation of the law. To better understand the factors behind such a risky revealed behavior, the study divided the observed violations into three categories of increasing risk behavior, called Type I, II, and III violations. Such classification of violations is typical in rail grade crossing safety studies. Sposato et al. (2006, p. 28), for example, defined the three violation types as follows:

- A Type I violation occurs when a motorist or pedestrian enters the crossing when the warning lights are flashing but before the gate arms have begun to move;
- A Type II violation happens when a pedestrian or motorist enters the crossing when the gate arms are in motion, either in their descent (before train arrival) or ascent (after train departure); and,
- A Type III, and riskiest, violation occurs as a motorist or pedestrian enters the crossing after the gate arms are in their horizontal position.

Upon classifying violations into the three categories, we computed the violation rate per gate activation (Table 34). This rate is, simply, the number of violations that occurred during the observation time interval divided by the number of distinct gate activations. Note that each pedestrian user violator was assigned exclusive membership to only one of the violation types.

Table 34. Violation Rates per Gate Activation

| US DOT Inventory No. | County Name | City Name | Street Name | 2006–2010 Collision History | Rate of Violation per Gate Activation | | | |
|------------------------|-------------|--------------|------------------------|-----------------------------|---------------------------------------|---------|----------|-------|
| | | | | | Type I | Type II | Type III | All |
| 608830M | Cook | Chicago | 119th St | 0 | 0.040 | 0.400 | 1.720 | 2.160 |
| 079493L | Cook | Riverside | ILL43/Harlem Ave | 3 | 0.000 | 1.984 | 0.127 | 2.111 |
| 173887G | Cook | Chicago | Nagle Ave | 5 | 0.833 | 0.833 | 0.167 | 1.833 |
| 079508Y | Cook | La Grange | US12/La Grange Rd | 3 | 0.149 | 3.931 | 0.337 | 4.416 |
| 174948Y | DuPage | Glen Ellyn | Park Blvd | 0 | 0.047 | 2.302 | 0.349 | 2.698 |
| 843811C | Cook | Chicago | Marquette Rd | 0 | 0.000 | 1.304 | 0.087 | 1.391 |
| 388040W | Lake | Deerfield | Osterman Ave | 0 | 0.000 | 0.421 | 0.000 | 0.421 |
| 079521M | DuPage | Hinsdale | Ped/Park St* | 0 | 0.000 | 0.000 | 0.333 | 0.333 |
| 174937L | DuPage | Villa Park | Ped/Villa Park Depot | 0 | 0.041 | 2.122 | 0.082 | 2.245 |
| 372128W | Cook | Elmwood Park | Ped/Elmwood Park Depot | 0 | 0.087 | 1.087 | 0.696 | 1.870 |
| All Crossings: Minimum | | | | | 0.000 | 0.000 | 0.000 | 0.333 |
| All Crossings: Maximum | | | | | 0.833 | 3.931 | 1.720 | 4.416 |
| All Crossings: Mean | | | | | 0.120 | 1.438 | 0.390 | 2.578 |

*Dedicated pedestrian crossing.

Clearly, there is considerable variation in the violation rates among the 10 crossing sites. Type I violation rates range from zero to 0.833. Similarly, Type II rates range from zero to 3.931, and Type III rates from zero to 1.72. Overall, the rates in all three violation types combined range from 0.333 in Hinsdale to 4.416 in LaGrange. It seems that the violation rate per gate activation varies with the volume of pedestrians using each crossing. This is probably best illustrated in the difference between the crossing at Park Street in Hinsdale which ranked tenth with the fewest pedestrian use, and LaGrange Road which had the greatest use. It is interesting that both of these crossings are on the same BNSF line with 3 tracks and more than 150 daily trains. In a negative manner, the Hinsdale Park Street crossing stands out because all 3 violations were Type III violations.

5.4 PEDESTRIAN COUNTS AT STUDY CROSSINGS

Pedestrian counts in each crossing location obtained from video observations are shown in Table 35. In all, 7,624 pedestrians were observed at the 10 crossing locations, at an average cost of

\$1.12 per pedestrian. Pedestrian counts on each side of each crossing were further summarized in 15-minute intervals; the resulting charts are shown in Appendix J.

Table 35. Pedestrian Counts at Study Crossings (from 12 midnight to 11:45 p.m.)

| US DOT Inventory No. | Street Name | Pedestrian Counts on Attached Sidewalks | | | | |
|----------------------|------------------------|---|-------|------|------|-------|
| | | North | South | East | West | Total |
| 608830M | 119th St | 202 | 148 | NA | NA | 350 |
| 079493L | ILL43/Harlem Ave | NA | NA | 516 | 82 | 598 |
| 173887G | Nagle Ave | NA | NA | 50 | 731 | 781 |
| 079508Y | US12/La Grange Rd | NA | NA | 918 | 1533 | 2451 |
| 174948Y | Park Blvd | NA | NA | 545 | 614 | 1159 |
| 843811C | Marquette Rd | 89 | 423 | NA | NA | 512 |
| 388040W | Osterman Ave | 102 | 72 | NA | NA | 174 |
| 079521M | Ped/Park St* | NA | NA | 35 | 16 | 51 |
| 174937L | Ped/Villa Park Depot | NA | NA | 655 | 363 | 1018 |
| 372128W | Ped/Elmwood Park Depot | NA | NA | 177 | 353 | 530 |

*Dedicated pedestrian crossing.

At the crossing on 119th Street in Chicago, 350 pedestrians were counted: 202 on the north side and 148 on the south side of the crossing (Table 35). The morning and evening peak periods are noticeable, with a few spikes of traffic midday (Appendix J). Pedestrians appear to favor the south sidewalk during the morning rush and the north sidewalk during the evening peak.

At the crossing on Harlem Avenue in Riverside, 598 pedestrians were counted: 516 on the east side and 82 on the west side of the crossing (Table 35) (very strong winds during the day of the survey shifted the camera focus from its calibrated position so that the west sidewalk at the crossing was not visible after 2:45:00 p.m. As a result, pedestrian counts between 2:45:00 and 11:45:00 p.m. (end of daily shift) were set to zero). The morning and evening peak periods are noticeable, with a few spikes of traffic midday (Appendix J). Pedestrians appear to favor the east sidewalk throughout the day.

At the crossing on Nagle Avenue in Chicago, 781 pedestrians were counted: 50 on the east side and 731 on the west side of the crossing (Table 35). The morning and afternoon peak periods are noticeable (Appendix J), indicating, perhaps, expected traffic during school start and end times. Pedestrians appear to favor the west sidewalk throughout the day.

At the crossing on LaGrange Road in LaGrange, 2,451 pedestrians were counted: 918 on the east side and 1,533 on the west side of the crossing (Table 35). There appears to be relatively heavy traffic throughout the day, more so on the west sidewalk (Appendix J).

At the crossing on Park Boulevard in Glen Ellyn, 1,159 pedestrians were counted: 545 on the east side and 614 on the west side of the crossing (Table 35). The morning and evening peak periods are noticeable, with a major spike of traffic during the afternoon school release (Appendix J). Pedestrians appear to be distributed almost evenly on both sides of the crossing, with the exception of the afternoon spike during which pedestrians (probably students) appear to favor, almost exclusively, the east side of the crossing.

At the crossing on Marquette Road in Chicago, 512 pedestrians were counted: 89 on the north side and 423 on the south side of the crossing (Table 35). The morning, midday, and

afternoon traffic patterns typical of the nearby school are evident (Appendix J). Pedestrians appear to favor the south sidewalk, where the nearby school is located.

At the crossing on Osterman Avenue in Deerfield, 174 pedestrians were counted: 102 on the north side and 72 on the south side of the crossing (Table 35). Traffic is generally stable during regular business hours (Appendix J), with an afternoon peak during school release time. Pedestrians appear to slightly favor the south sidewalk.

At the dedicated pedestrian crossing on Park Street in Hinsdale, 51 pedestrians were counted: 35 coming from the east side and 16 from the west side of the crossing (Table 35). The morning peak appears to coincide with school start time, when pedestrians appear coming, almost exclusively, from the east side (Appendix J).

At the Villa Park Depot crossing, 1,018 pedestrians were counted: 655 on the east side and 363 on the west side of the crossing (Table 35). The morning and evening peak periods for commuters are noticeable (Appendix J). Pedestrians appear to favor the west side sidewalk during regular business hours.

Finally, at the Elmwood Park Depot crossing, 530 pedestrians were counted: 177 on the east side and 353 on the west side of the crossing (Table 35). The morning and evening peak commuting periods are noticeable (Appendix J). Pedestrians appear to favor the west side sidewalk during regular business hours.

5.5 ANALYSIS OF CROSSING SPEEDS

Walking speed can vary dramatically depending on a variety of factors including age, purpose of walking trip, number of people walking together, ambient temperature, cultural differences, walking surface, ground incline, footwear, carrying method, and load (Knoblauch et al. 1996; Bohannon 1997; Attwells et al. 2006). The *Manual on Uniform Traffic Control Devices* (MUTCD) has long used 4.0 ft/sec as the recommended walking speed in setting the time for the pedestrian clearance (flashing “Don’t Walk”) phase for pedestrian signal installations. In the latest MUTCD (USDOT/FHWA 2009) the recommended walking speed has been reduced to 3.5 ft/sec for the pedestrian clearance phase, and 3.0 ft/sec for the entire “Walk/(flashing) Don’t Walk” interval (LaPlante and Kaeser 2007).

Not surprisingly, the great majority of the users in the video data were walking while crossing the tracks. While occasional poor visibility in the video data did not allow developing reliable estimates for the mode of crossing, of the 7,624 users observed, 7,161 (94%) were walkers and 463 (6%) were bicyclists. For comparison purposes, an estimate from the analysis of user interviews in the survey indicated that 94.9% of the users walked over the crossings in the study (Table 3), which compares well with the video observations. On the other hand, bicyclists appear to be somewhat underrepresented in the user survey (3.8%) compared with video observations (6%).

Considering that the vast majority of users observed were walkers, we expected that the literature about walking speeds would be relevant in our analysis once reasonable estimates for crossing times and distances were developed. The crossing time recorded in the video database was defined to be the time to traverse the distance between the outer rail at the near side and the outer rail at the far side of the crossing. To obtain reasonable speed estimates, we used Google Maps to measure the distances A–B, A–C, A–D, and B–E at each crossing, as shown in Figure 18 for a three-track crossing. We also observed the direction of travel (straight or diagonally) for each user. An estimate of the crossing speed was then obtained by the ratio of the crossing distance and the crossing time.

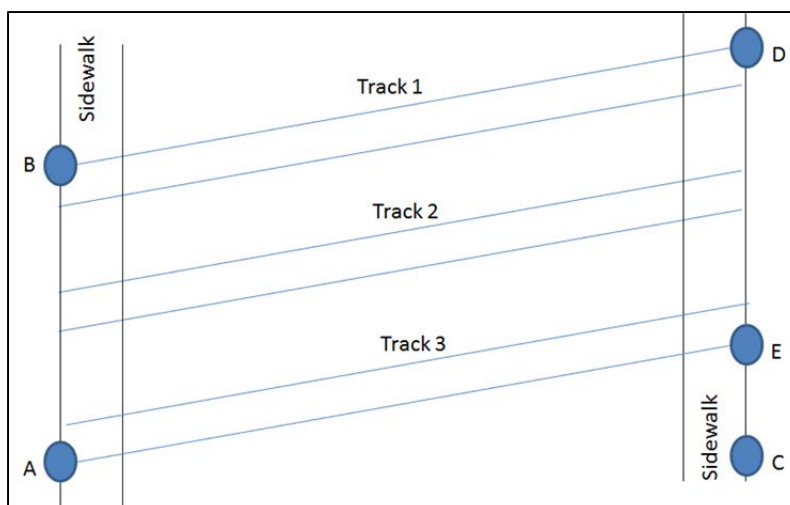


Figure 18. Crossing distances measured.

We were not able to validate in the field the distance measurements obtained using Google Maps. Moreover, the estimated distances should not be used for reference purposes outside of this study. For the purposes of this analysis, we assumed that the error distribution of estimated Google Maps crossing distance is uniform among the 10 study crossings. A similar assumption was made about the video crossing times estimated by different students at different times.

Statistics from the crossing speed distributions for walkers and bicyclists among the non-motorized users observed on video are shown in Table 36 along with the mean crossing time. Note that the walk mode in Table 36 includes people pushing a stroller/cart, walking with children, or walking their bicyclists. More specifically, of the 7,161 walkers, 55 were pushing a stroller/cart, 36 were walking with children, 6 were walking with children and pushing a stroller, 6 were walking a dog, 5 were walking a bicycle, and 5 were on a motorized wheelchair.

The bicycle mode includes people on bicycles, skateboards, and rollerblades, taking into account comparable crossing times. More specifically, of the 463 users on bicycles, there were 2 on rollerblades and 7 on skateboards.

The mean crossing time for the two-track crossing at 119th Street is obviously the shortest compared with the rest three-track crossings. The variations in crossing time among the nine three-track crossings is due to a number of factors including the particular submode of use among walkers or bicycles, the geometrical configuration of the crossings and the attached sidewalks, and the crossing surface material.

Overall, the speed distributions for bicycles were much more spread out compared with those for walkers, as can be seen by the interquartile ranges in Table 36. For bicyclists, the mean speed was 8.77 ft/sec, while the median speed was 8.00 ft/sec. The mode of the speed distribution for bicyclists was also 8.00 ft/sec. For walkers, the mean, median, and mode moments of the speed distribution were 3.71 ft/sec, 3.56 ft/sec, and 3.78 ft/sec, respectively.

Table 36. Crossing Speed Distributions

| US DOT Inventory No. (Tracks) | Street Name | N Walk (Bike) | Mean Crossing Time (sec) | Crossing Speeds (ft/sec) Moments and Quartiles | | | | |
|-------------------------------|------------------------|---------------|--------------------------|--|--------------|--------------|-------------|---------------------|
| | | | Walk (Bike) | Mean | Median | Mode | Stand. Dev. | Interquartile Range |
| | | | | Walk (Bike) | Walk (Bike) | Walk (Bike) | Walk (Bike) | Walk (Bike) |
| 608830M (2) | 119th St | 338 (12) | 6.70 (2.83) | 3.46 (7.00) | 3.00 (7.50) | 3.60 (9.00) | 2.17 (2.15) | 1.03 (4.50) |
| 079493L (3) | ILL43/Harlem Ave | 558 (40) | 10.31 (3.75) | 3.85 (11.58) | 3.78 (11.33) | 4.25 (11.33) | 1.49 (4.75) | 1.20 (4.42) |
| 173887G (3) | Nagle Ave | 771 (10) | 11.57 (3.60) | 3.89 (11.60) | 3.64 (13.33) | 3.64 (13.33) | 1.47 (2.33) | 1.37 (3.33) |
| 079508Y (3) | US12 / La Grange Rd | 2362 (89) | 10.66 (4.79) | 3.63 (8.78) | 3.40 (8.50) | 3.78 (11.33) | 1.48 (3.53) | 1.42 (4.53) |
| 174948Y (3) | Park Blvd | 1114 (45) | 8.71 (3.91) | 4.18 (10.46) | 4.00 (10.67) | 4.00 (10.67) | 1.58 (6.12) | 1.37 (4.27) |
| 843811C (3) | Marquette Rd | 492 (20) | 11.40 (6.80) | 3.31 (6.07) | 2.91 (5.87) | 2.67 (2.29) | 1.95 (2.77) | 1.54 (3.71) |
| 388040W (3) | Osterman Ave | 150 (24) | 8.40 (4.38) | 4.44 (10.51) | 4.25 (8.50) | 4.25 (8.50) | 1.56 (4.98) | 1.08 (5.67) |
| 079521M* (3) | Ped/Park St* | 49 (2) | 8.88 (2.50) | 4.73 (14.17) | 4.25 (14.17) | 4.25 (—) | 2.51 (4.01) | 2.27 (5.67) |
| 174937L (3) | Ped/Villa Park Depot | 876 (142) | 11.53 (6.42) | 3.17 (7.29) | 2.91 (6.40) | 3.20 (6.40) | 1.28 (4.07) | 1.09 (3.43) |
| 372128W (3) | Ped/Elmwood Park Depot | 451 (79) | 9.87 (5.01) | 3.85 (8.95) | 3.56 (8.00) | 3.56 (8.00) | 1.66 (5.21) | 1.09 (5.33) |
| All Crossings | | 7,161 (463) | 10.29 (5.13) | 3.71 (8.77) | 3.56 (8.00) | 3.78 (8.00) | 1.61 (4.69) | 1.39 (5.33) |

*Dedicated pedestrian crossing.

Turning the discussion to individual crossings, the mean speed for walkers ranged from 3.17 ft/sec in Elmwood Park to 4.73 ft/sec in Hinsdale. The rather high interquartile range of 2.27 ft/sec in Hinsdale is the result of a small sample and relatively many slow and fast walkers (i.e., runners). For bicyclists, the range was from 6.07 ft/sec at Marquette Road to 14.17 ft/sec in Hinsdale. The high-speed distribution spread of 5.67 ft/sec in Hinsdale is based on only two bicyclists. On the other hand, the equally high-speed distribution spread in Deerfield of 5.67 ft/sec includes relatively many fast and slow bicyclists.

The speed variations in Table 36 were likely the result of a number of environmental and behavioral factors. Demographic factors (i.e., gender or age) may also have been behind such variations, but such a conjecture could not be verified in many cases because of issues with video quality. Nevertheless, we were able to extract information for a number of factors from the video data. The analysis below discusses how crossing speeds are associated with the observed attributes.

5.5.1 Association Between Platoon Size, Violations, and Crossing Speed

Pedestrians at road crossings can use social information, such as the crossing behavior of others, and follow others across the road. Faria et al. (2010) found that people standing next to a crossing pedestrian tended to cross before other waiting pedestrians and that, on average, a person was 1.5 to 2.5 times more likely to cross if the person standing next to him/her had started to cross. In addition, males tended to follow others more than females.

On the other hand, crossing a road safely requires perceiving accurately whether crossing in front of oncoming traffic is possible, which in turn requires perceiving the relationship between environmental properties (the crossing distance and the available time) and one's walking abilities. Only while walking is perceptual information about walking abilities available; hence, a more accurate perception of whether crossing is possible is expected than when stationary. Thus, crossing from a standstill would require a larger safety margin (Oudejans et al. 1996), although other factors such as the perceived size of an oncoming car and the threat it poses, as well as age may also play a role (Mathey 1983; Harrell 1991; Sekuler and Blake 1990; Caird and Hancock 1994).

The distributions of platoon sizes by crossing are shown in Table 37. Overall, half of the video-observed users were solo crossers, with the other half being almost equally split between doubles and triples or greater. Considerable variation among crossings exist. For example, users at 119th Street and Hinsdale were mostly single crossers (75% or more), while only a third were single crossers at the Nagle Avenue crossing. Moreover, a third of the users were doubles at the Deerfield crossing, while less than one in seven were doubles at the Harlem Avenue crossing. Finally, more than a third of the users were triples or greater at the Marquette Road crossing, while only 6% were triples at the 119th Street crossing.

Table 37. Distributions of Platoon Size of Crossers by Crossing

| US DOT Inventory No. | County Name | City Name | Street Name | Platoon Size | | | | | |
|----------------------|-------------|--------------|------------------------|--------------|------|--------|------|------------------|------|
| | | | | Single | | Double | | More Than Double | |
| | | | | N | Pct. | N | Pct. | N | Pct. |
| 608830M | Cook | Chicago | 119th St | 261 | 74.6 | 68 | 19.4 | 21 | 6.0 |
| 079493L | Cook | Riverside | ILL43/Harlem Ave | 398 | 66.6 | 90 | 15.0 | 110 | 18.4 |
| 173887G | Cook | Chicago | Nagle Ave | 256 | 32.8 | 186 | 23.8 | 339 | 43.4 |
| 079508Y | Cook | La Grange | US12/La Grange Rd | 1,002 | 40.9 | 658 | 26.8 | 792 | 32.3 |
| 174948Y | DuPage | Glen Ellyn | Park Blvd | 562 | 48.5 | 286 | 24.7 | 311 | 26.8 |
| 843811C | Cook | Chicago | Marquette Rd | 222 | 43.4 | 118 | 23.0 | 172 | 33.6 |
| 388040W | Lake | Deerfield | Osterman Ave | 106 | 60.9 | 56 | 32.2 | 12 | 6.9 |
| 079521M | DuPage | Hinsdale | Ped/Park St | 42 | 84.3 | 8 | 15.7 | — | — |
| 174937L | DuPage | Villa Park | Ped/Villa Park Depot | 566 | 55.6 | 210 | 20.6 | 242 | 23.8 |
| 372128W | Cook | Elmwood Park | Ped/Elmwood Park Depot | 327 | 61.7 | 148 | 27.9 | 55 | 10.4 |
| All Crossings | | | | 3,742 | 49.1 | 1,828 | 24.0 | 2,054 | 26.9 |

To investigate the platoon effect on crossing speeds, we classified the observed pedestrians into three groups (solo, two, and more than two) and the crossing speeds into four groups (too slow, slow, fast, and too fast). Such classification allowed enough observations per category for statistical purposes. The highly significant value ($Q = 1875$, $p < 0.0001$, with 6 degrees of freedom) of the Pearson chi-square statistic (Agresti 2007) signifies that crossing speed and platoon size are statistically associated. Repeating the analysis, this time adjusting for each crossing using the Cochran-Mantel-Haenszel statistic Q_{CSMH} (Agresti 2007), we found ($Q_{\text{CSMH}} = 387$, $p < 0.0001$, with 1 degree of freedom), we found a clear monotonic association between crossing speed and platoon size: the larger a platoon size the slower its speed crossing the tracks. Although this is not a surprising finding, it implies that in certain situations with larger platoons crossing the tracks at the same time (e.g., getting on/off commuter/light rail, school release), the clearance interval is longer, suggesting a need to extend the warning time and provide more advanced warning.

The previous association between crossing speed and platoon size holds if, in addition to crossing location, we control for violation status (i.e., whether pedestrians were in violation of the signal/device). The Cochran-Mantel-Haenszel statistic ($Q_{\text{CSMH}} = 510$, $p < 0.0001$, with 1 degree of freedom) indicated that, controlling for crossing location and violation status, crossing speed is clearly associated with platoon size. The association also holds ($Q_{\text{CSMH}} = 371$, $p < 0.0001$, with 1 degree of freedom) if, instead of violation status, we control for violation type (Types I, II, and III).

The previous tests showed a clear association between platoon size and crossing speeds—but not the nature of the association. To do that, we estimated an ordinal logistic regression model (McCullagh and Nelder 1989) with the crossing speed as the dependent and the group size, and the other variables that we previously controlled for, as the independent variables. All coefficients were significant at the 99% confidence level.

The model estimates showed that groups of two (more than two) pedestrians were more than twice (more than 10 times) as likely to cross the tracks very slowly compared with solo pedestrians. Moreover, pedestrians who committed a Type I or Type II violation were more than twice as likely to cross the tracks very slowly compared with pedestrians who committed a far riskier Type III violation. Pedestrians who did not appear to commit any type of violation were more than three times as likely to cross the tracks very slowly compared with Type III violators. Clearly, pedestrians who took the most risk by crossing the tracks going through lowered gates found themselves with a need to cross the tracks in a hurry.

We also clustered the 10 crossings in 3 groups according to their violation rates (previously shown in Table 34). Crossings received low, medium, and high designations if they had less than one, between one and two, and more than two violations per gate activation, respectively. We found that pedestrians at medium and high crossings were almost twice as likely to cross the tracks very slowly.

5.5.2 Association Between Time of Day, Platoon Size, and Violations

Figures 19 through 21 present the hourly distributions of violation types as a percentage of the total number of violations (for each violation type) for solo pedestrians, two pedestrians, and more than two pedestrian. The time-stamps on the horizontal axis represent time intervals (e.g., 0:00:00 to 12:59:59, 1:00:00 to 1:59:59, etc.). It turns out that, controlling for the time of day, there is a very strong association between the type of violation and the platoon size ($Q_{\text{CSMH}} = 194$, $p < 0.0001$, with 1 degree of freedom).

More specifically, violations expectedly follow the patterns of pedestrian traffic during the day, i.e., a morning and an evening peak for all platoon sizes. Additionally, a rather pronounced spike of violation activity for groups of two or more pedestrians seems to coincide with the midday/early afternoon school release.

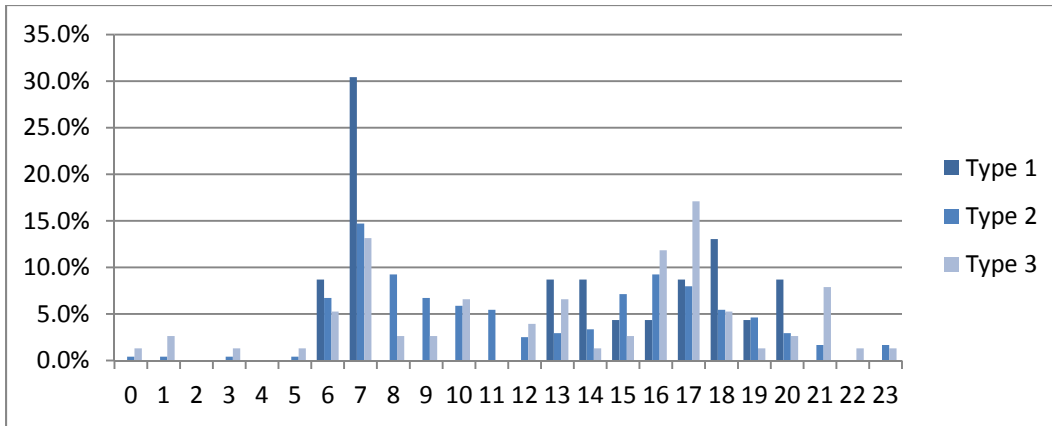


Figure 19. Hourly distribution of violation types for solo pedestrians.

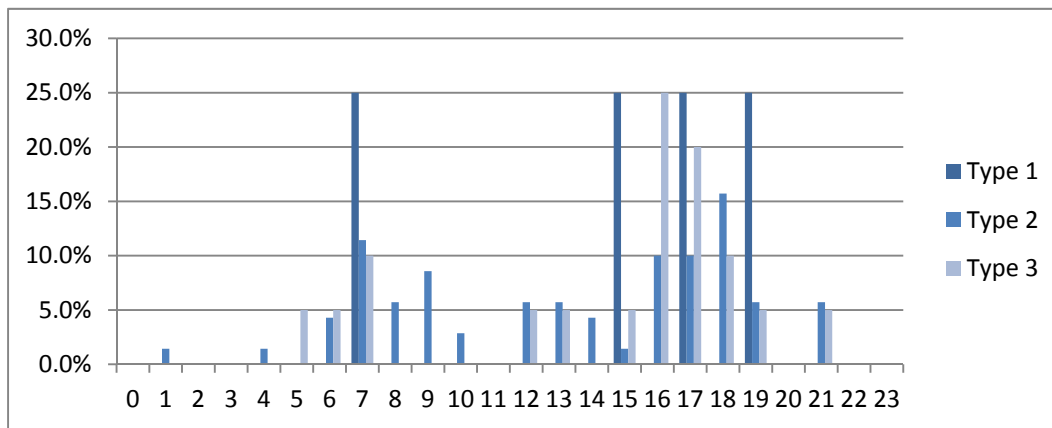


Figure 20. Hourly distribution of violation types for groups of two pedestrians.

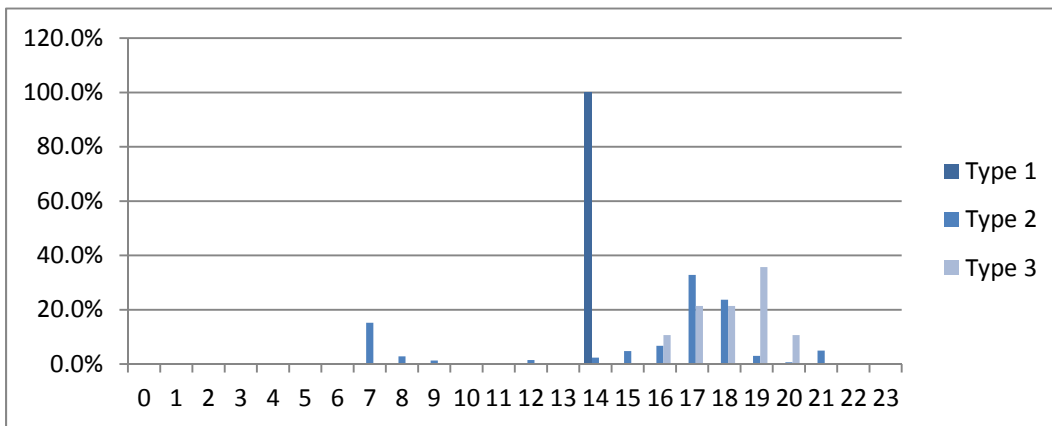


Figure 21. Hourly distribution of violation types for groups of more than two pedestrians.

5.6 ATTITUDINAL DIFFERENCES BETWEEN VIOLATORS AND NON-VIOLATORS

In earlier discussion, we noted that more than half (57%) of pedestrians observed (by video) crossing the tracks were in violation of activated warning devices and signs. This puzzling phenomenon presents a safety issue because, more often than, not pedestrian

fatalities at rail grade crossings involve this group of trespassers. In this section, we discuss attitudinal differences found between the two groups.

We investigated how platoon size affects violation attitudes. Overall, there is strong correlation between platoon size and violation attitudes ($Q_{CSMH} = 236$, $p < 0.0001$, with 1 degree of freedom), even controlling for the time of day ($Q_{CSMH} = 185$, $p < 0.0001$, with 1 degree of freedom). The results of the test statistic and the level of confidence (in parenthesis) for each crossing are shown in Table 38. Strong correlation between platoon size and violation attitude appears in all crossings except on Nagle Avenue, Marquette Road, and Osterman Avenue. Leaving aside the crossing on Nagle Avenue because of video issues (explained earlier), the other two crossings scored rather low (compared with the other eight crossings in the study) on violation rates per gate activation, with scores 1.391 and 0.421, respectively (Table 34). These correlations hold even after controlling for the time of day, although the “thinning” of the sample sizes affects the strength of the associations.

Table 38. Association Between Platoon Size and Violation Attitude

| US DOT Inventory No. | County Name | City Name | Street Name | Q_{CSMH} (Confidence Level) | Q_{CSMH} Controlling for Time of Day (Confidence Level) |
|----------------------|-------------|--------------|------------------------|-------------------------------|---|
| 608830M | Cook | Chicago | 119th St | 12.15 (>99%) | 5.76 (99%) |
| 079493L | Cook | Riverside | ILL43/Harlem Ave | 151.49 (>99%) | 81.61 (>99%) |
| 173887G | Cook | Chicago | Nagle Ave | 0.91 (66%) | 0.66 (58%) |
| 079508Y | Cook | La Grange | US12/La Grange Rd | 110.48 (>99%) | 98.20 (>99%) |
| 174948Y | DuPage | Glen Ellyn | Park Blvd | 31.67 (>99%) | 22.25 (>99%) |
| 843811C | Cook | Chicago | Marquette Rd | 0.43 (49%) | 1.09 (70%) |
| 388040W | Lake | Deerfield | Osterman Ave | 0.37 (46%) | 0.19 (37%) |
| 079521M | DuPage | Hinsdale | Ped/Park St | 6.14 (99%) | 2.59 (89%) |
| 174937L | DuPage | Villa Park | Ped/Villa Park Depot | 30.24 (>99%) | 31.81 (>99%) |
| 372128W | Cook | Elmwood Park | Ped/Elmwood Park Depot | 8.21 (>99%) | 3.12 (93%) |

Estimates from a logistic regression of violation attitudes against platoon size revealed that pedestrians in platoons of two committed a violation of activated warning devices and signals 16% more often than lone pedestrians. Similarly, pedestrians in platoons of three or more committed the same violation 222% more often than lone pedestrians. Moreover, three or more pedestrians crossing the tracks were 177% more likely to commit a violation compared with groups of two pedestrians. Such findings are in agreement with the literature about social behavior (Faria et al. 2010). These findings are independent of the time of day factor (daylight vs. nighttime).

5.7 VIOLATIONS, PEDESTRIAN GATES, AND TRAIN STATUS

5.7.1 Categorical Data Analysis

For each of the 10 crossings, we found a strong association between violation type and the direction a train was moving (i.e., incoming, outgoing), as shown in Table 39. All the Cochran-Mantel-Haenszel chi-square statistics in the last column (level of confidence in parenthesis) are estimated with 1 degree of freedom. The table shows that with a great level of confidence (99% or better) we can say that riskier pedestrian behavior, namely committing a Type II or III vis-à-vis Type I violation, is strongly associated with an outgoing (vis-à-vis an incoming train).

Table 39. Association Between Violation Type and Train Direction

| US DOT Inventory No. | County Name | City Name | Street Name | Q_{CSMH} (Confidence Level) |
|----------------------|-------------|--------------|------------------------|-------------------------------|
| 608830M | Cook | Chicago | 119th St | 311.93 (>99%) |
| 079493L | Cook | Riverside | ILL43/Harlem Ave | 389.76 (>99%) |
| 173887G | Cook | Chicago | Nagle Ave | 244.02 (>99%) |
| 079508Y | Cook | La Grange | US12/La Grange Rd | 1310.76 (>99%) |
| 174948Y | DuPage | Glen Ellyn | Park Blvd | 480.47 (>99%) |
| 843811C | Cook | Chicago | Marquette Rd | 259.82 (>99%) |
| 388040W | Lake | Deerfield | Osterman Ave | 53.21 (>99%) |
| 079521M | DuPage | Hinsdale | Ped/Park St | 49.96 (99%) |
| 174937L | DuPage | Villa Park | Ped/Villa Park Depot | 316.39 (>99%) |
| 372128W | Cook | Elmwood Park | Ped/Elmwood Park Depot | 326.37 (>99%) |

5.7.2 Regression Analysis

To measure the strength of the previous association, we estimated logistic regression models. The data of interest are the 1,780 pedestrians (Table 34) who were observed at the 10 crossings during gate activation periods. As already discussed, 1,021 of those pedestrians committed a violation against activated gates, whereas 759 did not commit a violation while crossing the tracks.

The dependent variable was a binomial (yes/no) variable of whether a violation was committed. The independent variables were the train direction, the number of pedestrian gates installed at a crossing, and the number of daily trains passing through a crossing. The train direction variable was ordered from not present, to gone, to coming, in a natural progression of increasing safety risk. We also experimented with a number of interaction terms between train direction, number of pedestrian gates, and number of trains in order to investigate their combined effect on committing a violation. Typical estimation results (i.e., degrees of freedom, parameter estimate and its standard error, test statistic, and confidence level) for each parameter of the selected model are shown in Table 40.

Table 40. Logistic Regression Estimation Results

| Parameter | DF | Estimate | Standard Error | Wald Chi-Square | Confidence Level |
|--|----|----------|-----------------------|-----------------|------------------|
| Intercept | 1 | 0.9601 | 0.1046 | 84.2042 | >99% |
| Number of pedestrian gates and train direction | 1 | -0.7752 | 0.1834 | 17.8657 | >99% |
| Number of pedestrian gates and train direction | 1 | -0.1339 | 0.0675 | 3.9327 | >95% |
| Number of pedestrian gates | 1 | -0.5512 | 0.0973 | 32.0980 | >99% |
| Pedestrians gates and trains | 1 | 0.00335 | 0.000808 | 17.1991 | >99% |
| Wald Confidence Interval for Odds Ratios | | | | | |
| Label | | Estimate | 95% Confidence Limits | | |
| Train direction (not present vs. gone) at average # of pedestrian gates (2.27) | | 0.234 | 0.109 | 0.500 | |
| Train direction (not present vs. coming) at average # of pedestrian gates (2.27) | | 0.173 | 0.076 | 0.390 | |
| Train direction (gone vs. coming) at average # of pedestrian gates (2.27) | | 0.738 | 0.547 | 0.996 | |
| 1 pedestrian gate at average # of trains (127.24) and train direction (not present) | | 0.407 | 0.289 | 0.572 | |
| 2 pedestrian gates at average # of trains (127.24) and train direction (not present) | | 0.165 | 0.084 | 0.327 | |
| 4 pedestrian gates at average # of trains (127.24) and train direction (not present) | | 0.027 | 0.007 | 0.107 | |
| 1 pedestrian gate at average # of trains (127.24) and train direction (gone) | | 0.772 | 0.711 | 0.839 | |
| 2 pedestrian gates at average # of trains (127.24) and train direction (gone) | | 0.596 | 0.505 | 0.703 | |
| 4 pedestrian gates at average # of trains (127.24) and train direction (gone) | | 0.355 | 0.255 | 0.494 | |
| 1 pedestrian gate at average # of trains (127.24) and train direction (coming) | | 0.883 | 0.757 | 1.030 | |
| 2 pedestrian gates at average # of trains (127.24) and train direction (coming) | | 0.779 | 0.573 | 1.060 | |
| 4 pedestrians gates at average # of trains (127.24) and train direction (coming) | | 0.607 | 0.328 | 1.124 | |
| 1 train at average # of pedestrian gates (2.27) | | 1.008 | 1.004 | 1.011 | |
| 5 trains at average # of pedestrian gates (2.27) | | 1.039 | 1.020 | 1.058 | |
| 10 trains at average # of pedestrian gates (2.27) | | 1.079 | 1.041 | 1.118 | |

All parameters are significant with 95% or better confidence. The reference category for the train direction was the category “coming.” On the basis of the data shown in the bottom half of Table 41, it is estimated that the predicted odds for being in violation (at a crossing with an average number of two pedestrian gates) against an activated warning device when the train was not present were 77% less compared with when the train was gone and 83% less compared with when the train was coming. Moreover, these odds were 26% lower when the train was gone than when the train was coming.

Similarly, each additional pedestrian gate (installed at a crossing with average daily train traffic of 127 trains) was associated with a 59% decrease in the predicted odds of being

observed to be in violation when a train was not present. When a train was gone, these odds decreased by 23% and by 12% when the train was coming.

The effect of multiple gates is even more dramatic. The predicted odds for being in violation at crossings (with average daily train traffic of 127 trains) equipped with two (additional) pedestrian gates decreased by 84%, and with four gates by 97%, when a train was not present. When a train was gone, two (four) additional gates decreased these odds by 40 (65%). Moreover, when a train was coming, two (four) additional gates decreased these odds by 22 (39%).

This finding merits attention because it is in agreement with pedestrian gate effects discussed in Chapter 4. It seems that pedestrian gates may have an even stronger effect on deterring actual (compared with stated) pedestrian behavior of crossing the tracks against activated warning devices.

5.8 VARIATION IN VIOLATIONS BETWEEN CROSSINGS

We will now examine whether the findings in the previous section are affected by variations in violation incidence between crossings. The framework of analysis was the well-developed statistical methodology of hierarchical linear models (HLM) (Bryk and Raudenbush 1992; Snijders and Bosker 1999). Recent transportation planning applications of the framework are discussed elsewhere (Metaxatos 2011; Thakuria et al. 2012).

There are several reasons why an HLM may be appropriate for this type of analysis. First, a multi-level model provides a convenient framework for studying multi-level data, especially because we would be interested in examining (1) cross-level effects of crossing-specific environmental factors and individual pedestrian-level attributes, and (2) whether crossing-level environmental profiles would make a difference in the variability of the propensity to be in violation of activated warning devices and signs at rail grade crossings among individual pedestrian users. Second, multi-level modeling corrects for the biases in parameter estimates resulting from clustering. In fact, the more highly correlated the observations are within clusters, the more likely that ignoring clustering would result in biases in parameter estimates. Third, multi-level modeling provides correct standard errors, and thus correct confidence intervals for hypothesis testing, and these generally will be more conservative than the ones obtained by ignoring the presence of clustering (Goldstein 1999).

5.8.1 Methodology

A brief presentation of the HLM methodological framework facilitates the discussion of the results. So far, we have been using the standard logistic regression model:

$$y_{ij} = p_{ij} + e_{ij}, \text{ with } \text{logit}(p_{ij}) = \log\left(\frac{p_{ij}}{1 - p_{ij}}\right) = \alpha + \sum_{k=1}^K \beta x_{kij}$$

where Y is a binary outcome variable (e.g., pedestrian i committed or did not commit a violation) and follows the Bernoulli distribution $Y \sim \text{Bin}(1, \pi)$; X 's are pedestrian-level predictors; α and β 's are the regression coefficients; $i = 1, \dots, I_j$ is the pedestrian-level indicator; $j = 1, \dots, J$ is the crossing-level indicator; and p_{ij} is the probability of committing a violation for pedestrian i at crossing j , conditional on X 's. The logit model assumes that pedestrian-level random errors e_{ij} are independent with moments $E(e_{ij}) = 0$, and $\text{Var}(e_{ij}) = \sigma_e^2 = p_{ij}(1 - p_{ij})$. With a simple algebraic manipulation, we calculated the probability function to be

$$p_{ij} = \frac{\exp(\alpha + \sum_{k=1}^K \beta x_{kij})}{1 + \exp(\alpha + \sum_{k=1}^K \beta x_{kij})}$$

It is easy to see that our data have two levels (pedestrian and crossing levels) and that pedestrians were observed at each crossing. However, the logistic regression model is a single-level model that does not account for the variation between crossings. A simple way to account for the effects of crossings is to add design (indicator) variables so that each crossing has its own intercept in the model. These crossing intercepts (called subject-specific intercepts) are used to measure the differences between crossings with

$$\text{logit}(\pi_{ij}) = \alpha_j + \beta x_{ij}$$

The intercepts can be specified as either fixed effects or random effects. The use of fixed intercepts, however, leads to increasing the number of additional parameters equal to the number of crossings minus one (nine, in this case). Treating the crossing intercepts α_j as a random variable with a specified probability distribution leads to the model:

$$\text{logit}(p_{ij}) = \alpha_j + \sum_{k=1}^K \beta x_{kij} \text{ with } \alpha_j = \alpha + u_j \text{ and } u_j \sim N(0, \sigma_u^2).$$

The errors u_j are the crossing-level random effects and are assumed to be independent of the pedestrian-level random errors e_{ij} . The crossing intercepts measure the differences between crossings (as the sum of a grand mean, α , and a deviation, u_j , from that mean) controlling for other effects. Combining the two levels into one equation, we obtain the logistic mixed model:

$$\text{logit}(\pi_{ij}) = \alpha + u_j + \sum_{k=1}^K \beta x_{kij}.$$

The model can be viewed as comprised of two parts: a fixed part that contains the overall intercept α and the linear combination of predictors $\sum_{k=1}^K \beta x_{kij}$, and a random part that contains two random effects (for the intercept u_j and for the within crossing residual r_{ij}).

5.8.2 Estimation Results

Evidence for the substantial crossing-to-crossing violations variation was investigated by means of an unconditional means analysis, which can be viewed as a one-way random effects analysis of variance (ANOVA) model. The analysis suggested that crossings do differ in the incidence of violation and that there was even more variation among pedestrians within crossings (the variance component within crossing was more than five times the size of the variance component between crossings). Moreover, the intra-crossing correlation (ICC), given by $ICC \approx \frac{\sigma_u^2}{\sigma_u^2 + 3.29}$, and defined as the portion of the total variance that occurred between crossings, was estimated to be 1.2%, which is relatively small but significant. This shows that there is a small amount of clustering of violation incidents within crossings that would not be accounted for by an ordinary logistic regression analysis.

The crossing-level variables in the logistic mixed model we estimated were (similar to the logistic regression model) the train direction, the number of pedestrian gates, and the number of daily trains. Of those fixed effects, only the interaction term between train direction and number of gates appeared to be significant with confidence 95% or better (Table 41). Typical estimation results (i.e., degrees of freedom, parameter estimate and its standard error, test statistic, and confidence level) for each fixed effect are shown in the top half of Table 41. The bottom half of the table shows the estimate odds ratios and confidence interval for each effect. On the basis of the information in the bottom half of Table 41, the following observations can be made:

- At crossings with two pedestrian gates, installing two additional pedestrian gates would decrease the odds of committing a violation by 24% when a train is gone compared with when a train is coming.
- At crossings with no pedestrian gates, installing two pedestrian gates would decrease the odds of committing a violation by 54% when a train is gone, and by 40% when a train is coming.
- At crossings with no pedestrian gates, installing four pedestrian gates would decrease the odds of committing a violation by 79% when a train is gone, and by 64% when a train is coming.

Table 41. Multi-Level Regression Estimation Results—Fixed Effects

| Parameter | Estimate | Standard Error | Wald Chi-Square | Confidence Level |
|--|----------|-----------------------|-----------------|------------------|
| Intercept | 1.0564 | 0.2749 | 3.84 | >99% |
| Number of pedestrian gates and train direction (not present) | -0.9685 | 0.2016 | -4.80 | >99% |
| Number of pedestrian gates and train direction (gone) | -0.3908 | 0.1009 | -3.87 | >99% |
| Number of pedestrian gates and train direction (coming) | -0.2556 | 0.1181 | -2.16 | >99% |
| Wald Confidence Interval for Selected Odds Ratios | | | | |
| Label | Estimate | 95% Confidence Limits | | |
| 2 additional pedestrian gates at crossings with 2 when train is gone vs. train is coming | 0.763 | 0.581 | 1.002 | |
| 2 additional pedestrian gates at crossings with none when train is gone | 0.458 | 0.308 | 0.680 | |
| 2 additional pedestrian gates at crossings with none when train is coming | 0.600 | 0.377 | 0.953 | |
| 4 additional pedestrian gates at crossings with none when train is gone | 0.209 | 0.095 | 0.462 | |
| 4 additional pedestrian gates at crossings with none when train is coming | 0.360 | 0.142 | 0.908 | |

The variance component representing variation between crossings diminished almost by half, from 4.1% to 1.6%. This shows that the combined effect of train direction and pedestrian gates explains a large (61%) portion of the (little) crossing-to-crossing variation in committing a violation. Moreover, the residual intra-class correlation decreased from 1.2% to 0.7%. We can view this residual intra-class correlation as a partial correlation that shows the similarity in committing a violation among pedestrians within crossings after controlling for the effect of train direction and pedestrian gates.

Overall, the analysis at both the crossing and pedestrian levels provided further evidence about the deterrence effect of pedestrian gates to committing violations against activated pedestrian gates. Such effects remained significant after controlling for crossing variation, train direction, and number of installed pedestrian gates at each crossing.

CONCLUSION

This analysis compiles in one report a large amount of information concerning pedestrian safety at highway-rail crossings with pedestrian access and pathway-rail crossings dedicated solely to pedestrian use. While the trend in incidents at all crossings has been a steady decrease in the rate and quantity of incidents, incidents involving pedestrians have remained relatively constant.

An extensive review of the literature pertaining to pedestrian safety at highway-rail crossings concluded that there is a wide variety of warning signs and devices used. Some are MUTCD compliant, but many are not. None of the warning signs and devices has undergone rigorous testing to develop effectiveness rates. In addition, there is not a standard method to quantify and evaluate pedestrian risk at highway-rail crossings. These findings were confirmed via extensive interviews with a large number of state agencies, federal and national organizations, and a number of experts from within the community of consulting engineers.

Ten locations were identified as hot spots of pedestrian activity suitable to conduct paper/pen manual user surveys as well as covert video observation. 312 valid surveys were gathered and more than 7,000 observations of pedestrian behavior at highway-rail crossings were recorded. The principle findings from the surveys indicate:

1. Train-activated warning devices are generally observed by users more often than passive warning signs.
2. The propensity of pedestrians to be in violation of activated devices and signs while crossing the tracks decreases when crossings are equipped with pedestrian gates.
3. Pedestrian gates had the highest level of awareness of all warning signs and devices.
4. Half of all respondents did not suggest anything to improve safety, but of the half that did: adding pedestrian gates was the most popular response, followed by increased enforcement and grade separation.
5. Pedestrians who took the most risk by ignoring lowered gates found themselves in need to have to cross the tracks in a hurry compared with pedestrians who adhere to the rules.
6. Larger groups of pedestrians are more likely to commit a violation against activated devices or signs compared with lone or groups of two pedestrians.
7. In certain situations with larger platoons crossing the tracks at the same time (e.g., getting on/off commuter/light rail, school start/end times), the clearance interval would be longer, which has potential implications for extending the warning times by providing more advanced warning.
8. Pedestrian gates have an even stronger effect on deterring actual (compared with stated) pedestrian behavior of crossing the tracks illegally, even after controlling for variations between crossings and train direction.

Future research needs to focus on developing methods to quantify the risk at highway-rail crossings with pedestrian access and at stand-alone pathway-rail crossings to the non-motorized users of such locations. Future research also needs to focus on rigorously quantifying the effectiveness of the range of potential treatments to reduce the risk to non-motorized users at highway-rail and pathway-rail crossings. Another potential resource topic would be to compare the predicted number of collisions for vehicles at highway-rail crossings with the anticipated number of pedestrian-train collisions at the same crossing (compare a vehicle-train APF and a pedestrian-train APF for a highway-rail crossing that has pedestrian access). The benefit of this research is to reduce the number of incidents that occur between trains and non-motorized users at all highway-rail and pathway-rail grade crossings.

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APPENDIX A SURVEY MATERIAL AND PARTICIPANT RESPONSES

INVITATION LETTER TO PARTICIPANTS

A letter similar to the one below was emailed to survey of states contacts requesting their participation in the telephone survey.

Dear [contact name],

Hello, my name is [student name] and I am a research assistant at UIC's Urban Transportation Center. We are conducting interviews for a research project that examines the effectiveness of current technologies at rail grade crossings when it comes to pedestrian conflicts. We also are interested in the costs and implementation of these technologies at pedestrian/rail crossings.

This project is funded by the Illinois Department of Transportation (IDOT) and we will use the interviews to catalog best practices in crossing technology, which can be utilized to help reduce pedestrian injuries and fatalities at grade crossings.

You have been chosen because you are a representative of [agency/business], and we would love to have your participation. We would appreciate your insights at the [state? local? will change depending on the contact] level, which we will include in our report to IDOT. The interview should take no more than an hour and will be conducted at your convenience. If you choose to participate, we will hold your confidentiality in the highest regard.

If you are interested, or have any questions, please contact me at 312-996-4820, or I will follow up with you in one week.

Thank you in advance.

TELEPHONE SURVEY QUESTIONNAIRE

The following survey instrument was developed by the researchers and approved by the study TRP. The questionnaire was emailed to state contacts and was used to conduct telephone interviews.

PEDESTRIAN / BICYCLIST WARNING DEVICES & SIGNS AT HIGHWAY-RAIL & PATHWAY-RAIL GRADE CROSSINGS

Grant: IDOT R27-96

TASK 2: INTERVIEWS WITH STATE AGENCIES

Conducted by a Research Team from the

Urban Transportation Center, University of Illinois at Chicago
412 South Peoria Street, Suite 340, Chicago, Illinois 60607
Voice (312) 996-4713, Fax (312) 413-0006, Email: pavlos@uic.edu

April – December 2011

Study Objectives: The study will determine best practices for providing effective warnings to non-motorized and special needs users at highway-rail and pathway-rail grade crossings that (a) inform the user of the presence of a crossing, and (b) inform the user to take appropriate action to prevent a collision.

Interview Objectives: Obtain information about: (a) relevant literature (e.g., internal studies, consultant reports, etc.); (b) agency experiences with planning, implementation and evaluation of warning devices at grade crossings; (c) cost estimates and/or actual costs of such warning systems; and (d) policies for use of warning signs for non-motorized users at grade crossings.

Applicability of Results to State of Practice: The study aims at reducing the number of incidents that occur between trains and non-motorized users at all highway-rail and pathway-rail grade crossings. This research will assist transit agencies in Illinois and other states in their planning, upgrading, and retrofitting of pedestrian/bicycle crossings.

General Information

| |
|--|
| Agency Name: |
| Address: |
| Agency Jurisdiction and Responsibilities at Pedestrian Crossings: |
| |
| Contact Name/Title: |
| Telephone/Email: |
| Familiarity with Grade Crossings Safety: Very Good / Good / Average / Below Average / Poor |
| Date of Interview: |
| Interviewer: |

Survey Questions

1. What types of non-motorist safety treatments have you installed at rail grade crossings? Please be specific as possible. Please send us any relevant literature you could share with us (e.g., internal studies, consultant reports, etc.).

- signage (e.g., highly reflective passive warning signs, dynamic signs)
- pavement markings
- detectable warnings (e.g., audible tones, verbal messages, and/or vibrating surfaces)
- channeling pedestrian traffic (e.g., different types of fencing, swing gates, zigzag or Z-gates)
- audible/visual warnings (e.g., low-rise flashing pedestrian signals, multi-use path flashing light signals)
- automatic pedestrian gates (e.g., short gate arms)
- second-train-coming electronic warning signs
- other

2. What types of Accessible Pedestrian Signals have you installed? Do these signals provide information about:

- the existence and location of the pushbutton
- the onset of the walk interval
- the direction of the crosswalk and location of the destination curb
- the clearance interval
- the crossing geometry through maps, diagrams, or speech
- the type of crossing surface (e.g., vibrating surface)

3. Please send us cost estimates and/or actual costs of the warning systems you have already installed. If possible, include a cost breakdown for design, installation, component, maintenance and operating costs.

4. How do you evaluate the cost-effectiveness of such safety treatments? Please send us any relevant literature you can share with us.
5. What criteria are you using for the selection of warning devices for deployment? Please send us any relevant literature you can share with us.
 - pedestrians collision experience at the crossing
 - frequency of inclement weather
 - pedestrian volumes and peak flows
 - train speeds, numbers of trains, and railroad traffic patterns
 - surrounding land-uses
 - sight distance for pedestrians approaching the crossing
 - skew angle of the crossing relative to the railroad tracks
 - multiple tracks
 - vicinity to a commuter station
 - installation/maintenance costs
 - other
6. How do you prioritize/make trade-offs between these factors during the selection process? Please send us any relevant literature you can share with us.
7. What engineering standards and guidelines do you apply to such crossings? Do you go above and beyond the guidelines of the MUTCD? If so, can you share that experience with us?
 - specific warning times for active pedestrian warning devices
 - ADAAG compliant crossing surface material
 - gate/flasher/bell assemblies
 - passive and active warnings
 - fencing
8. What are you doing to discourage trespassers at or in the vicinity of grade crossings? Please send us any relevant literature you can share with us.
 - fencing
 - landscaping
 - prohibitive signs
 - video monitoring
 - education/outreach
 - enforcement
 - other
9. How do you evaluate the effectiveness of such measures/approaches against trespassing? Please send us any relevant literature you can share with us.

10. Please describe your educational outreach activities (e.g., public awareness programs, partnerships with other organizations, etc.). How effective are they? Please send us any relevant literature you can share with us.
11. Please describe your enforcement initiatives (e.g., police, courts). How effective are they? Please send us any relevant literature you can share with us.
12. How do you foster engineering and sight improvements? How effective are they? Please send us any relevant literature you can share with us.
13. What is your overall budget for safety at grade crossings? For pedestrian safety? Can you provide a percentage cost breakdown among engineering, education and enforcement activities?
14. What funding sources do you make use of to promote pedestrian safety at rail crossings? Please share the list of federal, state and other discretionary programs that you make use of.
15. Please share with us your policies/warrants/standards for using warning signs for non-motorized users at rail grade crossings (e.g., minimum warning times at/near to/far from commuter stations, design/installation/operational guidelines, etc.).
16. What state and local regulations in addition to federal regulations apply to non-motorized users at rail grade crossings.
17. Please send us any studies you could share with us regarding accident analysis at pedestrian crossings in your state.

SURVEY PARTICIPATION CONSENT FORM

The following consent form was sent to survey participants for signing and was sent back to researchers in advance of the interview.

University of Illinois at Chicago

CONSENT FORM

Project Title: Pedestrian / Bicyclist Warning Devices & Signs at Highway-Rail & Pathway-Rail Grade Crossings

You are being asked to participate in the research conducted by Research Assistant Professor Paul Metaxatos, or by students of staff under the supervision of Dr. Metaxatos.

Purpose of the Study: The proposed research would identify and evaluate the effectiveness of existing technology in use at passive (signs and markings only) and active (flashing lights) highway-rail and pathway-rail grade crossings, as well as recommend and evaluate the effectiveness of new technology. This research would include designated walkways/bikeways such as city sidewalks, non-designated walkways/bikeways such as roadway shoulders, and passenger/transit station crossings.

This research will also review best practices used in other states to assist in determining when various warning technologies should be installed at pedestrian/ bicycle path crossings. This review along with the technology evaluation data would lead to the development of a set of recommended best practices applicable to Illinois rail for the installation of walkway/bikeway warning devices.

If you agree to participate in the research, you will be asked to participate in a semi-structured interview aimed at understanding your state/agency practices as it pertains to warning signs at rail crossings. The interview should take approximately one hour.

You understand that your participation in this study is entirely voluntary and that you can withdraw from the study at any time without penalty. The research team will exclude your name from any reports and likewise will do so with regards to maintaining your privacy. You understand that the interview will be recorded for the purposes of transcription and that the tapes will eventually be destroyed after the transcription and aggregation process.

You understand that your participation in this research will not pose any physical risks to you personally and that you can skip any questions you are not comfortable answering.

You understand that you will not directly benefit from participating in the research, but that the research may be of benefit to the future of freight transportation in this country.

If you have any questions about this study, feel free to ask them now or anytime throughout the study by contacting:

Dr. Paul Metaxatos, Research Assistant Professor
Urban Transportation Center
College of Urban Planning and Public Affairs

University of Illinois at Chicago
Phone: (312) 996-4713
e-mail: pavlos@uic.edu

If you have any questions about your rights as a research subject, you may write or call OPRS at the following address:

Office for the Protection of Research Subjects (OPRS)
1737, W. Polk Street, M/C 672
203 Administrative Office Building
Chicago, Illinois – 60612.
Phone: (312) 996 1711 or toll free: 866-789-6215
Email: uicirb@uic.edu

Agreement to Participate in Research:

I understand that in signing this consent form, I am agreeing to participate in the research and give Professor Metaxatos, and his associates, permission to present this work in written and oral form, without further permission from me.

Name (Please print)

Signature

Telephone

Date

INTERVIEW FINDINGS

This section discusses the findings from the interviews. The findings are based on electronic transcriptions of recorded interviews but any omissions or errors remain the responsibility of the authors. The presentation of the responses below is in alphabetical order by state. In the end of this section, responses from industry experts and federal sources are additionally presented.

Alabama

Alabama has very few pedestrian grade crossings and none of them are signalized.

California

Both Caltrain, the commuter rail operator from San Francisco to San Jose, and Metrolink, the six-county commuter rail operator in the Los Angeles metropolitan area, have installed gated and channelized pedestrian crossing designs. These safety treatments have automatic gate arms, detectable warning, channelization and swing gates for emergency exiting if swing arms are down. Caltrain has 40 to 50 such crossings. Metrolink is still in the process of upgrading. In Orange County, Metrolink has probably upgraded most of the 100 to 150 commuter rail crossings.

The City of Pasadena, a destination city with large employment centers, has installed four-quadrant gates in all three grade crossings of its light rail line (Metro Gold Line). Pedestrian treatments include pedestrian gates, swing gates, and fencing. The swing gates are adjacent to the pedestrian gates so that if anyone is in the track area they can use the swing gate to get out. Electronic bells are used instead of mechanical bells to mitigate the noise impacts to the residents. Additional treatments include two foot high "Look Both Way" signs which are posted on the swing gates, smaller flashing lights for pedestrians, and ADA detectable warning strips and truncated domes. Interestingly, all three crossings could be designated as Quiet Zones but because of the large number of pedestrian users the trains are allowed to blow their horns.

Accessible pedestrian signals providing messages routinely deployed at regular intersection crossings are not utilized at rail grade crossings since only the "Don't Walk" message basically needs to be conveyed. Another reason for the infrequent use of accessible signals (other than detectable strips and detectable yellow tiles just ahead of the pedestrian gates) at rail grade crossings is the lack of standardization among manufacturers.

Crossing upgrades would require holding a diagnostic meeting in accordance with the FHWA handbook on rail crossing safety, and have all the interested parties (the railroad, the roadway authority, the California Transportation Commission (CTC) as a regulatory body over railroad crossing safety, and private parties) provide input. The California Public Utilities Commission has the authority to order a certain configuration if there is no agreement, especially after a long (a year or two) negotiation process.

In 2004 the state adopted the national MUTCD standards for the first time and has included a number of local amendments. There is an ongoing conversation about how much the MUTCD needs to be followed at crossings because there are a lot of different types of pedestrian crossings. There are sidewalk crossings which are considered part of a regular public at grade crossing which would require compliance with the MUTCD, but some would argue that a crossing within a station would not require MUTCD compliance. For example, at Amtrak stations, there are pedestrian crossings within the station that just go from platform to platform which are not treated in any way. These crossings just have rubber panels and it is expected that the train operation rules, and the fact that the crossing is in a station will lead to a

safe situation. Then the other extreme situation is a pedestrian/bike path that goes across a commuter rail track. In those cases the requirements dictate having full channelization and sensing along the right of way, sensing along the pathway, pedestrian gate arms, flashing light signals, bells, and maybe advanced warning signs along the bike path, rendering the situation to almost a vehicular crossing in terms of safety treatments. There is certainly a full spectrum of crossing types in between the previous two opposite situations depending on whether the rail line is commuter or freight.

The freight railroads have not necessarily opposed these treatments, but they are reluctant because of the costs associated with maintaining pedestrian gate arms. In most cases that "kills" the project because even though the state might be able to fund the installation of a pedestrian gate arm under the federal Section 130 program, under the FRA regulations the railroad has to maintain it, and might incur liability if there was some type of incident. It is generally recognized that gate arms do require quite a bit of maintenance especially in urban areas. The railroads in general have been reluctant, although the commuter rail agencies have accepted it because they realize it is a major safety issue and effects their on-time performance and reputation.

It has not been generally possible to reach an agreement for gate installation in cases where the freight railroads own the right-of-way. In particular, Metrolink has substantial commuter rail operations over BNSF- or UP-owned track. In those cases the freight railroads want the issue addressed nationally before they commit to those types of improvements in one location. The Illinois project involving the installation of a second train warning sign is a good example of where the freight railroads are willing to work on an experimental project to see how it goes.

Since channeling of pedestrian traffic has become a big priority Caltrain and Metrolink have both published engineering standards on the topic. They have typical crossing layouts for different track skews and slightly different situations, including channelization along the sidewalk approach along both the railroad right of way side and the curb side toward the street. Their layouts include how that works with a swing gate, and an automatic gate arm coming up and down over the sidewalk in each quadrant, and how that location plays in with the placement of the vehicular gate arms, and the presence of the detectable warning on the surface and then the painted lines that resemble a crosswalk going across the tracks, delineating the pathway from one side to the other. Putting all these elements together is the important part and that is where the engineering standards are needed. At this point, Caltrain and Metrolink have a lot of experience using those standards.

There is a \$271 fine for improper usage of pedestrian crossings. It is a standard fine for trespassing at a station sign. Within stations often the configuration involves two tracks and a platform on either side, as well as an inter-track fencing, so that users don't jump across from one platform to the other, especially with express trains coming from behind stopped trains. It is probably a design standard for commuter rail agencies to put fencing between the tracks in the vicinity of the station, which is where signs saying don't try to cross from platform to platform can be seen, citing the penal code and the fines that are associated with. Based on observation but not statistical verification, these signs have been effective.

At a typical railroad crossing, accessibility issues may be secondary because the traffic signals are controlling the approach across the tracks. In situations, however, where the track is immediately adjacent to an intersection, accessible rules may become more important with the design configuration. One possibility is to install audible countdown pedestrian signals but this is a much more commonplace experience at adjacent signalized traffic intersections than at rail crossings themselves. There have been a few places on light rail transit crossings with "walk/don't walk" signals control movement across the track, but overall it is not standard practice.

In general, evaluation of the cost effectiveness of the safety treatments is not standard practice. Only recently a before/after evaluation within and adjacent to station crossings showed that safety improvements including a swing gate, pedestrian gate arms, and the channelization on the approaches were effective at reducing the number of people who would walk casually around the gate, or take a short cut over the crossing. The improvements were very effective in increasing compliance with pedestrian crossing laws and increasing the amount of time between when someone violated the warning devices and when a train arrived at the crossing. So the separation time was increased and violations were reduced.

The diagnostic review process for determining what kind of warning device to install is not well defined. When a safety improvement is being considered a comprehensive treatment is usually requested including swing gates, lights, bells and channelization. Then it becomes an exercise in determining tradeoffs among cost constraints, physical feasibility with the surrounding space and the number of tracks involved. The diagnostic review team usually includes the roadway authority, that is, the city or county, or possibly the state DOT if it's a state route. In addition, the railroad, and occasionally railroads and light rail agencies that share corridors are also involved. Typically the public agency such as the city or county would represent the public interest.

The selection criteria for warning devices vary on a case by case basis. For commuter rail, the higher train frequency and higher train speeds are the most important criteria. In cases where the diagnostic review process cannot reach a decision, the commission will install flashing light signals on the off quadrants to supplement the existing typical vehicular warning devices that are already installed on two of the quadrants. In addition and in combination with the standard treatment a detectable warning device would be installed in an effort to be in compliance with all the accessibility rules. The latter are interpreted in the context of ADA requirements, similar to an intersection, but at a railroad crossing a detectable warning device would be placed on each approach to the track. In each of the four quadrants pedestrian volumes are taken into consideration and in cases of high pedestrian-to-train volumes there is an effort to at least install off quadrant flashers and detectable warning.

In summary, the basic treatment involves installing detectable warning almost anywhere. This is simple as long as there is a paved approach. If there is a need for channelization then issues regarding the right of way would need to be resolved so that cost sharing issues about continuing maintenance are cleared out. If there is a need to additionally install automatic warning devices (e.g., flashing light signals and bells) then significant funding issues become a concern.

Despite the availability of a few guidelines regarding the selection of warning devices it often becomes necessary to follow such a rather convoluted process. This is because in those occasions one or another constraint is at work whether a cost or right of way issue. For example, there are situations with a roadway that is not wide enough and if a federal project is underway the process to acquire the necessary right of way as part of those at grade crossing improvement projects becomes impossible to navigate. In the absence of adequate right of way, it usually becomes impossible to produce accessible sidewalks of the proper ADA width. At that point some kind of shortcutting is done and this often means that there is not enough width to put in any other poles or additional swing gates off to the side. This is just an example of how certain options are not available.

Educational outreach activities are conducted in conjunction with Operation Lifesaver. There is a lot of outreach to schools and all kinds of professional drivers and enforcement efforts involving the railroad police. In addition, considerable effort is made to educate law enforcement personnel regarding the serious implications of trespassing, and the consistent enforcement of existing laws.

Trespassing is a big problem along commuter rail lines. There are different engineering fencing standards for Caltrain and Metrolink. In big-problem situations, basic chain link fencing

usually doesn't work because it is so easy to cut through, and if anybody wants to, it usually happens where people are climbing through as a short cut. There are a couple improvements that can be implemented. Metal bar type fencing may be used but it still has quite a big space so one can use a crow bar and create a hole or use a blow torch and make a hole quickly and easily. A step above that is vandal resistant fencing which has a tight weave. It is a bit taller and more difficult to cut through. Commuter rail agencies seem to make that decision based on how problematic trespassing is along a given section. In the past some freight corridors have experienced problems with dumping in urban areas that leads to urban blight. When people can drive onto the right of way other problems arise, in addition to the dumping. Along those corridors, the railroad has sometimes taken the initiative to put down a lot of K-rails (a particular specification of a Jersey barrier used for temporary concrete traffic barriers), and concrete blocks to try to prevent access along the right of way. Union Pacific, in particular, has been successful in putting K-rail and blocks, and preventing trucks from being able to drive onto the right of way in some cases with the worst problems.

There have been some efforts to study the trespassing problem in conjunction with the FRA. Trespassing incidents are organized in a database but it is difficult to maintain consistency with the location information and determine whether the incident occurred along the right of way. Occasionally, a mile post stamp may substitute for an unidentified crossing, but mile posts are sometimes difficult to clarify. Where possible, latitude and longitude information is more reliable. Trespassing is probably the biggest concern in the industry right now because while accidents at both pedestrian and vehicular crossings have been going down over the years, it has been trespassing incidents along the right of way that have remained steady or gone up in some cases.

Finally, pedestrian safety at rail grade crossings would benefit from the development of a device that is designated by the industry to be the standard with regard to devices used at such crossings. Such a standard would have similar functionality with the pedestrian phase of signals at regular street intersections. In rail grade crossings situations, however, there is an additional difficulty with property ownership issues because large dedicated safety devices may encroach on private property. On the other hand, smaller devices, or other audible warning systems would need to become an industry standard before it becomes universally accepted and used effectively in every such crossing.

Colorado

The state did not have any particular insights.

District of Columbia

The District does not have pedestrian-rail at grade crossings.

Florida

The Florida Department of Transportation (FDOT) has installed zigzag fencing and short arm gates across sidewalks, as well as pedestrian gates and detectible warnings for walking surfaces. Pedestrian gates are included in the final estimate prepared by the railroad. The average cost for one gate includes: \$833 for design, \$8,550 for gate assemblies, gate and foundation, \$1,284 for labor, and \$567 for annual maintenance for one track (\$712 for multiple tracks). Note that the operating costs are not easy to break down as they are the responsibility of the railroad.

With respect to selection criteria of warning devices for deployment, FDOT conducts an engineering study if the pedestrian traffic is thought to be high. At that time, if a sidewalk is not

provided over the crossing, the existence of footpaths, field observations, pedestrian generators, and sidewalk continuity are taken into account to determine if a sidewalk needs to be added. If the pedestrian study demonstrates that people are obeying the normal signal and gate system then the added pedestrian gates may not be warranted. At least one of the following has to be present to recommend the installation of pedestrian gates:

- Multiple tracks crossing where a pedestrian may attempt to cross from behind a stopped or parked train into the path of a second train.
- When pedestrian traffic during an average day is greater than 100 in each of any four hours or 190 in any one-hour or when the crossing is in close proximity to a school that has notable pedestrian traffic utilizing the crossing.
- There is a minimum of two scheduled trains per day or at least one in each of the peak hours used above.
- The location of the crossing is in close proximity to a passenger rail station.

Regarding engineering standards, FDOT uses its Standard Index for Railroad Grade Crossing Traffic Control Devices No. 17882, as well as the FHWA's Manual on Uniform Traffic Control Devices for Street and Highways, and the US Department of Transportation's Railroad-Highway Grade Crossing Handbook for the installation of gate/flasher/bell assemblies. ADA standards also apply. Engineering and sight improvements are initiated during Diagnostic Field Reviews. In addition, FDOT is in the process of reviewing public-passive crossings and as part of the field reviews the team is evaluating the sight distance of these crossings throughout the state. Engineering improvements are evaluated for effectiveness through a before and after report.

An illustration of FDOT Design Standards for an accessible sidewalk at railroad crossings and detectable warning placement can be seen in <http://www.dot.state.fl.us/rddesign/DS/10/IDx/304.pdf> (Index 304, Sheet 6). The Design Standards have an option for pavement markings on shared use path or bike lanes to warn cyclists about approaching rail crossings. This is Index 1347, Sheet 1 in <http://www.dot.state.fl.us/rddesign/DS/10/Int/E/17347.pdf>. The MUTCD has some guidance in Chapters 9 on smaller scale signs that may be used in conjunction with shared use paths or sidewalks (<http://mutcd.fhwa.dot.gov/pdfs/2009/part9.pdf>). Whether or not crossing arms are extended or installed at rail crossings of shared use paths or sidewalks is location specific.

To discourage trespassers at or in the vicinity of grade crossings, the Railroads are installing NO TRESPASSING SIGNS on their property and conduct education/outreach with Operation Lifesaver presentations and law enforcement blitzes. FDOT believes that public safety awareness efforts are difficult to measure as they often depend on what incidents did not occur. Nevertheless, Operation Lifesaver provides a measure of the success of the program at www.oli.org. Operation Lifesaver works with local law enforcement throughout the year to educate and enforce existing laws related to highway-rail grade crossing safety and trespassing on railroad property. The state of Florida also conducts a special enforcement week effort each year.

The State of Florida allocates \$7.5 million each year for the elimination of hazards at highway-rail grade crossings. Pedestrian safety is evaluated during field reviews; however, no specific amount of funding is set aside. Other funding resources for pedestrian issues include: safe routes to school and state safety funds. Operation Lifesaver education and enforcement funding is provided by railroad partners and varies year to year.

Illinois

The Illinois Commerce Commission (ICC) has statewide regulatory authority over all freight railroad operations as well as Amtrak operations when they are operating on property owned by freight railroads. In addition, the ICC has the statutory responsibility to improve safety at public highway-rail crossings in the state. The agency currently has three track inspectors, two hazardous material inspectors, three signal and train control inspectors and one operating practices inspector within a very extensive rail safety improvement program that currently receives 42 million dollars a year from the state grade crossing protection fund.

With approximately 7,200 miles of railroad track, the rail system in Illinois is the country's second largest, including the largest rail freight hub in Chicago (ICC, 2009). Currently, there are 8,066 highway-rail grade crossings in Illinois, of which 797 are on state roads, and 7,269 are on local roads (ICC, 2009). There are 2,812 highway-rail grade-separated crossings (bridges) in the state (ICC, 2009). Another 4,648 grade crossings are on private property, which are not under the jurisdiction of the state, and there are also 162 private bridge structures (ICC, 2009). There are also 390 pedestrian grade crossings and 91 pedestrian grade separated crossings (bridges) in Illinois (ICC, 2009). Nationally, Illinois is second only to Texas in the total number of highway-rail crossings (ICC, 2009).

In Illinois, the deployment of warning devices at exclusive pedestrian grade crossings is not a standard practice. More frequently, pedestrian approaches at existing rail-highway grade crossings receive safety upgrades concurrently with those planned for vehicular traffic. Moreover, accessible pedestrian signals are not usually considered in either setting.

Interestingly, both IDOT and ICC don't participate financially in the establishment of quiet zones. IDOT does not because the FHWA basically does not want the agency to use Section 130 funds for this purpose. This is because the quiet zones eliminate the horns being sounded which creates a deficiency which results in a decreased safety effectiveness. Additional funding would then have to be committed to bring back the safety effectiveness to the former desired level. This is likely the reason why the FRA would like having a prior corridor study conducted so that potential deficiencies introduced by eliminating whistle-blowing can be eliminated by the additional deployment of, say, constant warning time, or median treatments (to prevent vehicular traffic from going around the lowered gates) at all the crossings of the corridor. Staff of the ICC also believe that establishment of quiet zones results in a decrease in safety effectiveness.

Quiet zones may not also be beneficial for pedestrians. It is habitual for pedestrians or motorists using a grade crossing to stop, look, and listen for train horns. Pedestrians familiar with the particular crossings in a quiet zone may eventually adapt their crossing behavior to the absence of train horns. It would be harder to do so for visitors or tourists unfamiliar with the location. Similarly, pedestrian users trespassing on rail property while using earphones to listen to electronic devices may not be able to hear an incoming train. Below is a more specific discussion about engineering, education and enforcement relevant activities in the state.

Engineering

Once a year IDOT invites applications for safety upgrades at rail grade crossings through the Local Rail/Highway Grade Crossing Safety Program. The applications require local authorities to supply information on the following:

- Crossing characteristics including: (a) crossing surface type; (b) road surface type; (c) roadway width; (d) crossing width; (e) angle of crossing; (f) shoulder type (if applicable); (g) shoulder width; (h) ADT; (i) speed limit; (j) intersecting roads; (k) number of school buses; (l) hazardous materials; and (n) emergency vehicles.
- Train characteristics including: (a) existing warning devices; (b) number of tracks (industrial, switching, other); (c) trains per day (passenger, freight, switch, other); (d) train speed (passenger, freight, switch, other); and (e) simultaneous movements.
- An expected crash frequency (ECF) value computed from the formula:

$$ECF = 0.0000013 \times ADT \times Trains/Day \times "B" \text{ (see table below for "B" Factors)}$$

Table 1. B Factors – Basic Values for Railroad Protection Devices

| Components (Currently in Place) | Basic Values |
|---|---------------------|
| Crossbucks, traffic volume less than 500 vehicles per day | 3.89 |
| Crossbucks, urban | 3.06 |
| Crossbucks, rural | 3.08 |
| Wigwags | 0.61 |
| Flashing lights, urban | 0.23 |
| Flashing lights, rural | 0.93 |
| Gates, urban | 0.08 |
| Gates, rural | 0.19 |

Source: BLR 04100-I (Rev.12/13/11)

- Description of the project and estimated cost

A review of the applications, occasionally jointly with the Illinois Commerce Commission, results in the project selection. Currently, IDOT continues placing a stronger emphasis on signal and circuitry related projects as opposed to crossing surface projects. Additional emphasis is being placed on locations with rail lines hosting passenger trains, locations with increased numbers of trains or vehicles, and at locations having a collision history. Moreover, signal related projects are eligible for 100 percent federal funding (IDOT, 2011).

Additional criteria considered during the diagnostic review process include pedestrian traffic (e.g., how many pedestrians approximately use a crossing) as well as the surrounding land uses such as:

- Where are the traffic generators both from the highway side and the pedestrian side?
- Are there recreational facilities in the area?
- Is there a park or a school, or a bike and hike trail in the vicinity?
- Are there any intersections nearby?
- What is the line of sight?

- Is there proximity to a commuter station?

Additional concerns seem to emerge because of high speed rail projects in the state. One such issue is that of the additional warning time required to activate signals in advance of high speed trains. Currently, the typical warning time at crossings where pedestrians may be present is between 20 and 30 seconds for conventional speed trains. In an environment with 110 mile an hour trains there would be a need to provide confirmation signals to the train crew and the onboard computer that the crossing is clear likely requiring a warning time of at least 80 seconds. The question about how pedestrians will react to such extended warning times at pedestrian crossings remains to be determined. This is because currently most of the warning time is built into the time that the train occupies the crossing. When high speed trains begin to operate most of the warning time is going to be built into the time for the train approaching the crossing. Therefore, there would be an extended warning time where the crossing remains unoccupied while a high speed train cannot even be seen on the horizon. This situation will require “reeducation” of the public, especially in areas where crossings are very near to each other.

Costs

The general scarcity of cost information on pedestrian safety upgrades at rail crossings makes the information obtained from IDOT and reported below very relevant for our study. The related crossing (AAR DOT # 260804E) is located at the Illinois Prairie Path at the EJ&E Railway tracks near Batavia, Illinois. The crossing involves one mainline track equipped with STOP signs. Safety upgrade includes: (a) the installation of pedestrian flashing light signals, crossing gates and bells controlled by Constant Warning Time (CWT) circuitry; and (b) advance warning signs and pavement markings as required by the MUTCD.

The estimated railroad cost (with 100% Federal participation) is \$65,169. The estimated cost breakdown including material and work can be seen in Table 2.

Table 2. Cost Estimates for Signal Work to Add Warning Devices at Diehl Road for Relocated East Crossing, Multi-use Pathway

| Material Costs | | | | |
|------------------------------------|-----------------|--------------|------------------|-------------|
| Item | Quantity | Units | Unit Cost | Cost |
| XLC w/Plugboard | 2 | EACH | \$1,300.00 | \$2,600.00 |
| Vital Logic Gate | 1 | EACH | \$700.00 | \$700.00 |
| LED Flasher & Gate Assembly, 2-Way | 2 | EACH | \$8,000.00 | \$16,000.00 |
| Arm, E-Z Gate, 8 –16’ | 2 | EACH | \$530.00 | \$1,060.00 |
| Foundation, S-2 | 2 | EACH | \$550.00 | \$1,100.00 |
| Battery, Ni-Cad, 340 AH | 11 | EACH | \$390.00 | \$4,290.00 |
| Wire, 2c/6, T10456 | 300 | FEET | \$1.70 | \$510.00 |
| Cable, 7c/6, 9c/14, T12481 | 300 | FEET | \$5.25 | \$1,575.00 |
| Landfill | 1 | LOT | \$2,000.00 | \$2,000.00 |
| Misc. Signal Material | 1 | LOT | \$3,000.00 | \$3,000.00 |
| Subtotal Material | | | | \$32,835 |
| S&C Labor Costs | | | | |
| Item | Gang Days | Cost/day | Cost | |

Table continues, next page

| Material Costs | | | | |
|---------------------------------------|-----------------|--------------|------------------|-----------------------------------|
| Item | Quantity | Units | Unit Cost | Cost |
| 6-man Signal gang | 6 | \$1,860.00 | \$11,160.00 | |
| Miscellaneous Labor Costs | | | | <i>Table continues, next page</i> |
| Item | Quantity | Units | Unit Cost | Cost |
| Preliminary Engineering | 1 | L.S. | \$500.00 | \$500.00 |
| Construction Engineering | 1 | L.S. | \$500.00 | \$500.00 |
| Accounting | 1 | L.S. | \$100.00 | \$100.00 |
| Total | | | | \$1,100.00 |
| Total Labor Costs | | | | \$12,260.00 |
| Other Costs | | | | |
| Item | Quantity | Units | Unit Cost | Cost |
| Per Diem/Business Expense | 1 | L.S. | \$4,320.00 | \$4,320.00 |
| Rental of Equipment | 1 | L.S. | \$1,200.00 | \$1,200.00 |
| Sales Tax on Material | 1 | L.S. | \$2,298.00 | \$2,298.00 |
| Total Other Costs | | | | \$7,818.00 |
| Total Direct Costs | | | | \$52,913.00 |
| FAPG ADDITIVES | | | | |
| Material (4.20% of \$32,835) | | | | \$1,379.00 |
| Signal Labor (89.34% of \$11,160.00) | | | | \$9,970.00 |
| Engineering Labor (83.29% of \$1,000) | | | | \$833.00 |
| Accounting Labor (74.34% of \$100.00) | | | | \$74.00 |
| Total FAPG ADDITIVES | | | | \$12,256.00 |
| Total Direct Costs | | | | \$52,913.00 |
| Grand Total FAPG Basis | | | | \$65,169.00 |

Another example involves the installation of pedestrian flashing light signals and gates controlled by CWT circuitry at Illinois Prairie Path crossing (AAR DOT # 289852E) at the CC&P Railroad Company tracks in Elmhurst, Illinois. The estimated cost breakdown is shown in Table 3.

Table 3. Cost Estimates for Signal Work to Install Warning Devices at Multi-use Pathway Crossing

| Item | Quantity | Units | Unit Cost | Cost |
|--------------------------------------|-----------|------------|-------------|--------------|
| Landfill | 1 | LOT | \$3,000.00 | \$3,000.00 |
| Misc. Signal Material | 1 | LOT | \$10,000.00 | \$10,000.00 |
| Crossing Materials Package | | | | |
| HXP-3R2 | 1 | EACH | \$27,000.00 | \$27,000.00 |
| Highway Xing Analyzer | 1 | EACH | \$3,500.00 | \$3,500.00 |
| XLC w/Plugboard | 2 | EACH | \$1,300.00 | \$2,600.00 |
| Vital Logic Gate | 1 | EACH | \$700.00 | \$700.00 |
| Rectifier, NRS 18120, 40A | 1 | EACH | \$700.00 | \$700.00 |
| Rectifier, NRS 15110, 20A | 1 | EACH | \$500.00 | \$500.00 |
| LED Flasher & Gate Assembly, 2-Way | 2 | EACH | \$8,000.00 | \$16,000.00 |
| Arm, E-Z Gate, 8 – 16' | 2 | EACH | \$530.00 | \$1,060.00 |
| Bell, Electronic | 2 | EACH | \$385.00 | \$770.00 |
| ScadaNet RTU Remote Crossing Monitor | 1 | EACH | \$2,750.00 | \$2,750.00 |
| Spread Spectrum Radio Package | 1 | EACH | \$8,800.00 | \$8,800.00 |
| Foundation, S-2 | 2 | EACH | \$550.00 | \$1,100.00 |
| Battery, Ni-Cad, 250 AH | 11 | EACH | \$275.00 | \$3,025.00 |
| Battery, Ni-Cad, 340 AH | 9 | EACH | \$390.00 | \$3,510.00 |
| Pre-Wired Aluminum Bungalow, 6X6' | 1 | EACH | \$18,000.00 | \$18,000.00 |
| Wire, 2c/6 | 2100 | FEET | \$1.70 | \$3,570.00 |
| Cable, 3c/2, (Pwr) | 100 | FEET | \$3.87 | \$387.00 |
| Cable, 7c/6 | 500 | FEET | \$3.52 | \$1760.00 |
| SUBTOTAL MATERIAL | | | | \$108,732.00 |
| S&C LABOR | | | | |
| Item | Gang Days | Cost/Day | Cost | |
| 6-Man Signal Gang | 22 | \$1,860.00 | \$40,920.00 | |
| 2-Man Comm. Gang | 8 | \$450.00 | \$3,600.00 | |
| SUBTOTAL S&C LABOR | | | \$44,520.00 | |
| MISCELLANEOUS LABOR | | | | |
| Item | Quantity | Units | Unit Cost | Cost |
| Preliminary Engineering | 1 | L.S. | \$2,500.00 | \$2,500.00 |
| Construction Engineering | 1 | L.S. | \$300.00 | \$300.00 |
| Accounting | 1 | L.S. | \$200.00 | \$200.00 |
| SUBTOTAL MISCELLANEOUS LABOR | | | | \$3,000.00 |
| TOTAL LABOR | | | | \$47,520.00 |

Table continues, next page

| Item | Quantity | Units | Unit Cost | Cost |
|---|----------|-------|-------------|--------------|
| OTHER | | | | |
| Item | Quantity | Units | Unit Cost | Cost |
| Per Diem/Business Expense | 1 | L.S. | \$15,840.00 | \$15,840.00 |
| Rental Equipment | 1 | L.S. | \$4,400.00 | \$4,400.00 |
| Power Service | 1 | L.S. | \$6,000.00 | \$6,000.00 |
| Sales Tax on Material | 1 | L.S. | \$7,611.00 | \$7,611.00 |
| Contract-Crossing System Wiring | 1 | L.S. | 6,000.00 | \$6,000.00 |
| Freight on Crossing Package | 1 | L.S. | \$3,300.00 | \$3,300.00 |
| Container Rental | 1 | L.S. | \$975.00 | \$975.00 |
| Contract Engineering | 1 | L.S. | \$6,000.00 | \$6,000.00 |
| TOTAL OTHER | | | | \$50,126.00 |
| TOTAL DIRECT COSTS | | | | \$206,378.00 |
| FAPG ADDITIVES | | | | |
| Material Additive (4.20% of \$108,732.00) | | | | \$4,567.00 |
| Signal Labor Additive (89.34% of \$44,520.00) | | | | \$39,774.00 |
| Engineering Labor Additive (74.34% of \$200.00) | | | | \$149.00 |
| TOTAL OTHER | | | | \$50,126.00 |
| TOTAL DIRECT COSTS | | | | \$206,378.00 |
| TOTAL FAPG ADDITIVES | | | | \$46,822.00 |
| GRAND TOTAL FAPG BASIS | | | | \$253,200.00 |

A third example of estimated costs involves safety upgrades at a crossing (AAR/DOT # 843811C) on Marquette Rd. and 67th St. in Chicago that was also part of survey and video monitoring activities reported in later chapters. The total estimated project of \$933,668 breaks down into:

- The installation of warning devices at an estimated cost of \$778,874. The cost division was \$698,874 for the Grade Crossing Protection Fund (GCPF) and \$80,000 for the City of Chicago. Specific upgrades include installing Four Quadrant Gates, including in-pavement vehicle detector loops, constant warning time circuitry, event recorder, remote monitor, and pedestrian gates at the Marquette Road crossing, by the railroad company;
- The installation of fencing and pedestrian swing gates at an estimated cost of \$48,869 (100% out of the GCPF) ; and
- Roadway/crossing surface renewal at an estimated cost of \$105,925 (100% out of the GCPF).

Note that the ICC utilizes the GCPF, a state-only funding source, to assist railroads and local communities to pay for safety improvements at highway-rail crossings on the state's local road system. In general, the ICC incurs 85 to 95 percent of installation costs for automatic

warning devices at public grade crossings while the railroads pay all of the cost to maintain and operate the signals. If a local agency has enough money to help pay the cost, the ICC requests them to pay 10% of the installation cost. In the current economic environment, local participation in the cost sharing has become very difficult.

Despite the availability of cost information on a project-by-project basis it appears that dedicated funding for cost effectiveness studies is lacking. There has been a limited experience with cost-effectiveness analysis of safety treatments at rail-highway grade crossings. However, pedestrian safety has not been the focus of such studies.

Education, Enforcement and Outreach

The ICC has had a significant commitment to the Illinois Operation Lifesaver (IOL) organization actively participating in the coordination of IOL activities (e.g., identifying and training new volunteers and presenters working closely with local law enforcement and the railroads). With additional special FRA grants the ICC can reach in public education (e.g., PEERS studies). Unfortunately this type of funding came as an earmark and is not expected to be available in the future.

It takes a strong interest from local advocates to leverage available funding and ensure the continuity of effective education, outreach and enforcement safety campaigns at pedestrian-rail grade crossings. The Elmhurst Police Department, for example, is involved in numerous related activities. They teach Operation Lifesaver (OL) classes in grade schools, for the driver's education program, and community groups. Once or twice a year, the agency produces fliers that are distributed to commuters at train stations or are left on parked cars at commuter parking lots. The fliers themes are rotated around and cover specific details of relevant laws in rail crossings and other issues. Additional activities include the production of three different public service announcements through the Elmhurst Cable Commission. A related video clip can be viewed at <http://www.elmhurst.org/index.aspx?nid=338>.

Moreover, police officers certified as OL presenters or trainers offer classes to the interested general public or police officers from other departments about how to become presenters or trainers of OL programs. For example, officers assigned to be first responders to rail-related collisions are being taught how to run that investigation. From a police standpoint, a train is not defined as a vehicle. Therefore, during an investigation a collision between a train and a vehicle (e.g., car, truck, or motorcycle) will be reported on an Illinois crash form. However, if the collision is between a train and a pedestrian it would normally be a death investigation, which would go on a general case report for the Elmhurst Police Department (in this case).

The agency does not employ a particular methodology regarding the types of safety activities conducted at rail crossings. They are willing to try any idea that could draw the attention of pedestrians and other users of rail crossings. In addition to public announcements, the agency will put up signage (e.g., fliers on the commuter cars, posters in train stations or in businesses) or conduct safety blitzes, where police staff would talk to commuters and hand out information and perhaps promotional items (e.g., pen, pencil, Frisbee, mug, etc.) that would keep crossing safety as a forethought.

The effectiveness of such OL activities is verified by collision statistics (Figure 1). The community was experiencing about two to three fatalities per year prior to the program and only one fatality in the 17 years the program has been in place. Overall, the agency estimates that during this period a total of 32 lives have been saved (based on an average fatality rate prior to the program). The agency believes that this estimate is not affected by the impact of safety upgrades of warning devices at crossings during that time.

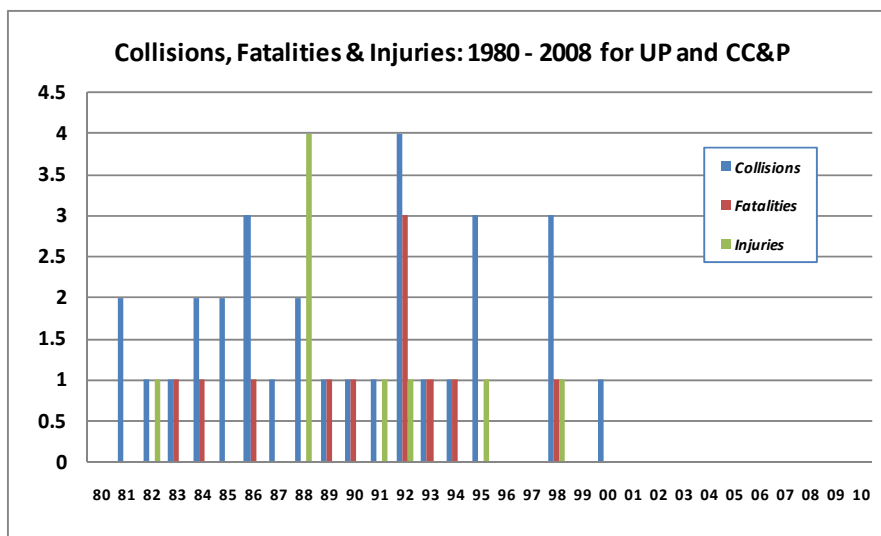


Figure 22. 1980-2010 Collisions, Fatalities & Injuries for UP and CC&P.
(Source: Elmhurst Police Department)

The program started very slowly in 1994 with no dedicated budget at all. Officers would simply go out and write tickets and hand out fliers. Additional training as an OL instructor occurred mostly on regular duty time and there was a little bit of crime prevention funds spent on buying fliers. As the program got a little bigger, it received support from the small traffic enforcement budget of ten to twenty thousand dollars and had officers conducting enforcement at grade crossings. Later, about seven or eight years ago, the agency was involved in the PEERS (Public Education and Enforcement Research Study) program which provided about \$60 thousand for the first couple years but has now diminished to about \$25 thousand in its last year. This funding is additionally used for paying officers to teach the OL classes, for purchasing promotional items, and supplementing the filming of the public service announcements. However, it is still uncertain whether the community will provide funding for such activities once the PEERS grant money expires, and diversion of enforcement funds (e.g., collected through fines) for outreach activities would require new state legislative action.

According to experts at the Elmhurst Police Department who acknowledge the rising number in trespassing fatalities and incidents, the emphasis on prevention through education and outreach activities varies from city to city and state to state. In Illinois it is mainly the local community police departments that conduct such activities and this is probably the norm among other states. In addition, comparisons among cities within a state and among states are not particularly helpful. Overall, experience shows that with adequate funding, along with the participation of an enthusiastic police department the benefits of enforcement and outreach can be compounded.

The same experts offered an insightful observation regarding the increase in trespassing activity that we have not seen in the literature. They argued that, in most cases, train tracks were built before available land was developed. Once development began, less desirable properties in the vicinity of rail tracks are (by necessity of a jurisdiction's master plan) oddly shaped and since they cannot fit a regularly-shaped building, they are normally used for public parks, school facilities, etc. For example, in Elmhurst the biggest problem with trespassers are not people in the fringes of society, but high school kids because a public high school is right along the rail tracks and kids frequently use those tracks as shortcuts (because the designated crossing is further away) on the way home, or to a parking lot to where their car is parked, or to a store on the other side of the tracks. Several other towns have a similar problem.

Elmhurst Police is trying to address the problem by: (a) using aggressive enforcement placing three officers in the parking lot across the track; (b) teaching OL classes in the driver's education program at the school; (c) conducting informational blitzes at the high school (e.g., posting a sign saying "*Elmhurst Arrests Railroad Trespassers*"); and (d) using four high school students to produce the trespassing video that is being aired on the local cable channel.

In terms of seasonality effects, it appears that trespassing violations at the high school appear to increase in the beginning of the school year with each new freshman class. Violations seem to drop off later as students become more receptive to safety messages, or adjust their behavior accordingly once they become familiar with police trap points. What is important from a safety standpoint is to continue with the campaign even after the number of violations seems to taper off because soon enough violators would return to their own habitual behavior. In addition, enforcement should not happen in any predictable way, say, every Tuesday or Wednesday, but rather three or four times continuously, then stop, then again in a couple of weeks. Such action has an additional deterrent potential as ticketed students spread the word around among their peers.

Another interesting point regarding enforcement campaigns raises the issue of the need for a cultural shift among police officers. Officers may not see trespassing at rail racks any different from jaywalking which they seldom write a ticket for. In addition, when the fines for violators increased to \$500 for a short period of time (it is now down to \$250), there was some confusion among ticketing officers about the stiffness of the fine vis-à-vis lower fines for more serious offenses (e.g., DUI or theft). Their argument was "*hey, if he wants to walk across and kill himself then he doesn't hurt anyone except himself*". This is why it is necessary to have available motivated officers willing to write these tickets or teach the safety classes to spread the message out.

Such activities would need funding and administrative support from the leadership in the police department, elected officials and city management to back up ticketing practices even when prominent citizens are affected. If any of these pillars is not available enforcement campaigns will not be as effective, and persistence in creative ways is necessary as no one method will do it all.

Iowa

In Iowa there have been only limited efforts for safety improvements at pedestrian grade crossings and only in conjunction with rail-highway grade crossings upgrades. The city of Marshalltown is the only such recent example.

A diagnostic review team conducts site visits to assess crossings with safety upgrades needs in general and not with pedestrians in mind. The review team will gather the physical characteristics of the crossing, evaluate the train traffic and speed, collect road information such as AADT, review sight restrictions at the crossing, and make recommendations for safety improvements.

The Iowa DOT uses the guidelines from the MUTCD and the FHWA's Grade Crossing Handbook. They don't currently have an MUTCD supplement developed specifically for the state.

Issues with trespassers are the responsibility of local highway jurisdictions and Operation Lifesaver activities. The state is not involved in educational outreach for safety initiatives.

Louisiana

The attention of the Louisiana DOT is focused on pedestrian crossings within the confines or near the rail-highway crossings. Separate pathways are almost exclusively bike

paths crossing the rail tracks. All safety upgrades occur in association with those at the associated rail-highway crossing. In some cases with relatively increased pedestrian traffic and lower railroad speeds the department has installed crossbucks with an LED stop sign underneath it. Rail-highway crossing surfaces are usually extended far enough to the sides to meet the sidewalk approach.

The department has not had experience with pedestrian channelization so far because of the largely low pedestrian volumes. There has been only one pedestrian gate paid for by the local municipality (Lafayette) that was installed on a sidewalk parallel to the rail-highway crossing in the 1980s. In addition, multiple-track signs alert about the possibility of a second train coming.

Trespassing is discouraged through fencing. Evaluation studies have reflected only on the aesthetic attributes (e.g., sturdier and taller fences vis-à-vis lower chain ones). Moreover, the DOT is actively involved with the local Operation Lifesaver operations.

The state receives about \$4 million annually for rail-highway crossings safety through various federal safety programs supplemented by local funds. There is no separate breakdown for pedestrian crossings.

Maryland

A number of non-motorist safety treatments have been installed at rail grade crossings including: (a) smaller sized crossbucks, advance warnings, and STOP signs with the same sheeting used on highway signs; (b) pavement markings similar but smaller in size to those used on highways; (c) short arm gates, where the sidewalk or trail is adjacent to a highway, operating on same track circuitry; and (d) several second-train-coming electronic warning signs in commuter rail stations where passengers cross the tracks to embark/debark trains going in the opposite direction. However, there are no Accessible Pedestrian Signals (APS) installed in highway-rail crossings (and even more so in pedestrian-rail grade crossings) since all of the resources available to this end are prioritized for highway-highway intersections.

Several criteria are used for the selection of warning devices for deployment including: (a) pedestrian volumes and peak flows; (b) train speeds, numbers of trains, and railroad traffic patterns; (c) surrounding land-uses; (d) sight distance for pedestrians approaching the crossing; (e) skew angle of the crossing relative to the railroad tracks; (f) multiple tracks; and (g) vicinity to a commuter station. However, no particular methodology is used to prioritize/make trade-offs between these factors during the selection process. Regarding engineering standards and guidelines the state applies those documented in the MUTCD and the FHWA's Highway-Rail Crossing Handbook.

Several approaches to discourage trespassers at or in the vicinity of grade crossings are used including fencing, landscaping, prohibitive signs, education/outreach, and enforcement through the railroad police when available. There is no formal evaluation of the effectiveness of such measures/approaches against trespassing. If there is no feedback such as reports or complaints then the measures used are deemed effective.

Additional educational outreach activities (e.g., public awareness programs, partnerships with other organizations, etc.) involve working with Maryland Operation Lifesaver to identify public outreach targets. Again, a formal evaluation process regarding the effectiveness of such activities is lacking. Moreover, several initiatives such as the "Trooper on the Train" trips quite a few years ago seemed to have raised police enthusiasm for enforcement.

Michigan

The Michigan DOT is responsible for safety at public rail grade crossings including pedestrian crossings. The focus is mainly on highway-rail crossings, but pedestrian crossings receive standard treatments including warning signs, pavement markings, corrals and mazes

and, occasionally, pedestrian gates and flashing lights. Occasionally, at trail crossings fencing is applied at some length to channel pedestrians through the actual crossing and prevent them from becoming trespassers. With the advent of some of the ADA compliance requirements, if an enhancement of rail-highway grade crossing impacts the associated sidewalk then funding will be provided to install truncated domes on sidewalk approaches; but this will only happen if there is a change in the crossing footprint, that is, if the project's work necessitates the removal of existing sidewalk which will then be replaced with one equipped with truncated domes.

In terms of cost-effectiveness of safety improvements, the agency would follow practices similar to those encountered in general motorist crossing safety updates. This involves determining the actual cost of the treatment, projected cost over time, and estimating potential collision reduction using cost-benefit models available in the FRA and FHWA websites. Yet, it was unclear whether such analysis has ever been conducted in individual pedestrian crossing safety upgrades.

Criteria used during selection of warning devices for deployment include: pedestrian volumes, peak flows, train speed, number of trains, railroad traffic patterns, sight distance for users approaching the crossing, angle of the crossing relative to the tracks, number of tracks, surrounding land uses, and maintenance/installation costs. The reason for the last criterion is that the agency responsible for the pedestrian facility will be sharing the maintenance cost under state regulations. In addition, the method that takes these criteria into consideration for decision making is a rather informal diagnostic site process involving engineering judgment vis-à-vis a more formalized template- or model-based method (see Appendix B).

The Michigan DOT has funded the local Operation Lifesaver (OL) program that is involved in enforcement and education activities with local schools, police departments, first responders, and training to help reduce the number of trespassing incidents. The larger (Class I) railroads have their own enforcement personnel and share resources in monitoring trespassing activities. Moreover, when local entities request for safety upgrades, the Michigan DOT provide the regulatory environment but the requesting authority is charged with the entire cost of the upgrade.

Cost-effectiveness evaluation of safety upgrades use data from Operation Lifesaver as well as FRA crash data. The analysis focuses mostly on reducing collisions between motorists and trains and not so much on mitigating trespassing. This is because the data is not consistently accurate since trespassing incidents (not on crossings) are frequently recorded as occurring at the nearest public roadway crossing. For example, trespassing may have happened a mile down the tracks where somebody is hiking, fishing, snowmobiling, hunting and generally doing something far removed from the crossing, but it is still tracked with the identification number of the nearest crossing. Given the limited funded available for safety improvements the focus remains the motorist rather than non-motorist accidents at rail crossings. Furthermore, there is no requirement to spending public monies to mitigate safety concerns (e.g., trespassing) on private property that is unrelated to the public right of way.

Sight and engineering improvements at crossings are addressed during a diagnostic review. Additionally, safety inspectors informally look at all crossings every 24 months. If there are sight distance concerns, they are noted and shared with the proper authorities (i.e. the railroad) to follow up.

In general, there are two sources of funding for safety improvements, federal and dedicated state monies, but there is no specific portion set aside exclusively for pedestrian crossings. Improvements in such crossings that are separate from a highway-rail crossing become a local funding issue. If, on the other hand, there is an issue with a particular highway-rail crossing that is accessed by pedestrians through, say, a sidewalk, then consideration will also be given to that pedestrian access, e.g., by installing lights and gates further away from the road and the cantilever to allow for a longer gate structure to also cover the sidewalk. This way,

there would be no need for a separate pedestrian facility, but the particular configuration still affords the pedestrian user the protection of the actual motorist warning device.

Michigan does not have a commuter rail or light rail operation and, therefore, it does not experience the same level of local concerns related to the people who are walking to the train, or arriving at the last minute trying to board a train using dedicated pedestrian crossings. Including Amtrak there is not enough train traffic and the station stops are not that many and are sited in isolated locations with dedicated overhead walkways and dedicated parking lots. Additionally, there are no multiple freight tracks with other passenger trains moving (as in the Chicago area). So the train traffic is very light and predictable and most of the locations are very clearly marked.

Minnesota

The Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) provides approximately \$5.7 million per year for rail safety projects in Minnesota. The following types of projects are eligible for funding under this program:

- Various types of signals and signal upgrades
- Crossing closures and consolidations
- Improving sight conditions by removal of visual obstructions
- Improving roadway geometrics and/or grades

In addition, railroad-highway grade crossing safety is funded under 23 USC Section 130. The federal participation for railroad-highway grade crossing safety improvement projects is 90 percent. A minimum 10 percent matching share from a source other than another federal fund will be required. Normally it is expected that the local road authority will pay the 10 percent local match. If a local road authority agrees to close a crossing in their jurisdiction, it may qualify for 100 percent funding. A limited amount of state funds are available for minor grade crossing safety improvements. These funds are used as the match for system-wide or corridor projects, or they are used to partially fund projects that cannot be funded with federal funds.

The Minnesota Department of Transportation (MnDOT) is only responsible for pedestrian crossings that are located within the roadway right of way. That would include a sidewalk within a road right of way, but would not include a path or trail that's freestanding and away from a roadway.

The department installed a sophisticated safety system in a northwest corridor of the state in Morehead, MN which is a quiet zone with the entire right of way fenced. In addition to gates at the crossing, there are also emergency exit gates which only open in one direction from the tracks out. In this manner, if someone (e.g., a person on a wheelchair) is trapped somewhere along the fenced right of way there is still a chance to get out of the way using a marked exit.

In other occasions the department has installed pedestrian mazes, and flashing lights based on using the accident history at the crossing as a guide. Since there isn't any particular set of guidelines, a lot depends on the railroad. Some railroads are more comfortable with certain types of pedestrian treatments than others. All gated crossings are equipped with an audible warning device. The use of truncated domes is rather infrequent.

The agency does not identify high hazard locations particular to pedestrian users. For motorists, high hazard locations are identified using the FRA's Accident Prediction Formula. Crossings with an accident prediction rate of .04 (1 accident in 25 years) or greater are considered high hazard locations. In addition, the agency evaluates railroad-highway grade crossing safety concerns identified by local road authorities, railroads, local planning

organizations and Mn/DOT District staff. These crossings often have an accident prediction rate less than .04, but may have characteristics, such as restricted sight lines, that warrant review.

The ranking and selection process is conducted annually outside the Metro Area and every two years in the Twin City/Metro area. Each year a new high hazard list is generated. The project review process consists of compiling the high hazard location list and adding to it the local requests. An on-site preliminary (also called a diagnostic) review is conducted at each identified crossing with the road authority, railroad and Mn/DOT Rail Admin staff. The following information is provided by the railroad/local road authority during the on-site review:

- The most recent traffic count
- Plans for any future road work
- Information and traffic projections for any development

The on-site review includes evaluation of the following:

- Verification of traffic count, train count and school bus count
- Sight restrictions in crossing quadrants
- Roadway and railroad grade crossing geometrics
- Impact of nearby roadways to the crossing (including storage distance restrictions)
- Review of adjacent crossings to determine whether crossings can be closed or consolidated
- Whether any of the trackage through the crossing can be retired

The final component of the diagnostic review process is to develop recommendations as to the appropriate warning device for the crossing. The staff may make low cost recommendations (e.g. additional signing, vegetation removal) or forward recommended safety improvements for active warning devices (e.g. flashing light signals, cantilevers and/or gates) for prioritization with other transportation related projects.

New Jersey

In New Jersey, there are 1,652 public grade crossings including pedestrian crossings adjacent to rail-highway crossings and approximately 30 pedestrian only crossings. Of all public grade crossings 513 have flashing lights and gates. The New Jersey Department of Transportation (NJDOT) has utilized various types of signs (the design in Figure 2 has also been in use in Elmhurst, Illinois), pavement markings, channelizing devices and gates. A 'second train coming' sign has been used twice in places with pedestrian incidents. One of the most used signs is a large sign that says 'warning: trains approach from both directions' (Figure 3). One of the audible tone verbal messages being used is 'incoming train, stand behind the yellow line' for passenger stations.

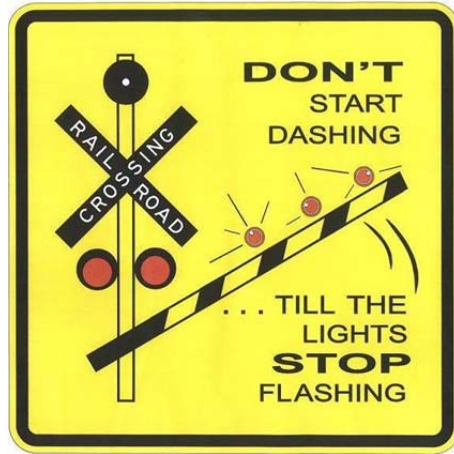


Figure 23. A pedestrian crossbuck sign used by the NJDOT.



Figure 24. A common sign for trains approaching in both directions.

Accessible pedestrian signals are not typically used. In light rail crossings used by schoolchildren they have utilized lowered warning signs (at three and a half feet) along with signs at the regular height.

The diagnostic review process examines several criteria to determine the need for safety upgrades including the train speed, number of trains, railroad traffic patterns and surface condition. In freight operations the starting point is whether the train is pull or push operation. Additionally, the pedestrian volumes and peak flows are examined and crossings near school sites receive priority. Sight distance for pedestrians approaching the crossing, and pedestrian collision experience at the crossing are additional criteria. Finally, in crossings with multiple tracks, the skew angle of the crossing relative to the railroad tracks, as well as the surrounding land use are taken into consideration.

In terms of engineering standards and guidelines the state follows the MUTCD and the grade crossing handbook. New Jersey Transit has designed additional signage not necessarily within the MUTCD standards but that have been found to be effective in their operations and NJDOT is supportive of this practice.

To discourage trespassers at or near gate crossings fencing, landscaping, and no trespassing signs are used in conjunction with Operation Lifesaver (OL) education and outreach activities. The NJDOT has a very active participation in OL operations. Anecdotal evidence shows that randomly-spaced safety blitzes (e.g., weekly but different days every one to three months at a different location), in particular those involving the rail and/or local police have been very effective. In a particular situation where a freight train comes through the middle of the town, the local judge required NJDOT to install 'no trespassing' signs along the railroad in both directions prior to enforcement which allowed tickets to be honored in court. This also allowed police to confiscate drugs, firearms, and other illegal possessions from people that were trespassing on railroad property.

The FY 12 DOT's budget for safety is about nine million dollars, \$6.8 million federal and \$2.2 million state money. The state portion is flexible as it can be allocated into multiple projects or reserved for a single project. The federal portion would usually pay for more expensive technological upgrades.

North Carolina

Within the state, on rail lines under FRA regulation, there is one location at which a Florida-style Z (chicane) crossing approach has been installed and one location at which dwarf crossing signals/gates were installed. NCDOT funded and provided civil design for the Z crossing, in Apex, NC on CSX. The electro-pneumatic dwarf crossing signals/gates, on a short line railroad, were funded by the Pinehurst Resort (a private concern) for a cart path, and are activated via a preemption interconnect with an adjacent road crossing signal system. There is one additional location, adjacent to the Fayetteville, NC Amtrak station, at which there is a plan to include "Second Train Coming" signs (based at least partly on Illinois practice with Metra, the commuter rail operator in northeastern Illinois).

Beyond the above, there are no other locations on FRA-compliant railroads with unique pedestrian crossing safety countermeasures. The Charlotte Area Transit System (CATS) operates the one FTA-regulated light rail system extant in NC at this time.

North Dakota

The Department of Transportation does not receive requests regarding pedestrian safety issues too often mainly because of low population. The department implemented pedestrian mazes in the Fargo quiet zone and other quiet zones are receiving additional signing but no additional pedestrian gates or flashers. Finally, the department assists with the safe routes to school program which allows for additional signing where needed.

Oregon

The standard practice is not using pedestrian gates at grade crossings for the fear of entrapment. However, there are no ordinances or other regulations promulgating such a policy. TriMet (the public transportation provider in Portland) is the only provider in the state that uses swing gates and power control swing gates at their light rail stations. An additional regulation for all public crossings requires cutting the vegetation 250 feet on each side of the crossing.

Sidewalks along the edge of a road are rarely carried through a grade crossing. The reason they don't usually move the sidewalk in front of the gate arm is because they want the existing traffic control devices sited as close to the edge of the road as possible for visibility purposes since Oregon is such a brushy state.

Safety upgrades are prioritized based on a diagnostic review process that examines a number of criteria (e.g., number of tracks, engineering design, number of trains, train speed, etc.), but decisions are usually based on a consensus among relevant stakeholders rather than on a formal cost-effectiveness methodology. Limited federal funds are focused mostly on installing active warning signs at rail-highway grade crossings. In the process pedestrian safety concerns are taken into account as needed.

Particular attention is being paid to investing safety funds for signal reliability at crossings. Once the safety equipment is installed the railroad is responsible to maintain it. The state Department of Transportation distributes annually about \$100,000 in state funds to railroads for grade crossing signals. The railroads can use these funds for maintenance (e.g., lights and new gates), but other than that, there are very few requirements about how the monies are being spent so long as they keep the funding in the state of Oregon.

The Oregon Department of Transportation participates in activities to mitigate trespassing with localities. The agency has its own program to install trespassing signs with level 2 railroads. There used to be additional involvement with Operation Lifesaver activities about seven years ago but this relationship has been severed due to an administrative decision. TriMet is probably more heavily involved with education and outreach activities given the high volume of trains (about 200 daily) on their tracks.

Texas

The Texas Department of Transportation (TxDOT) is involved in projects for pathways and sidewalks under what's typically referred to as the Federal Section 130 program, a safety program to install warning devices and crossing surfaces at public railroad crossings. The most typical type of warning devices is an audible warning, which is typically referred to as a bell or electronic bell that is mounted on the railroad crossing signal mast. Additionally, TxDOT has installed some tactile devices on the pathway and have had very limited or no use of pedestrian gates, Z-gates or specific pedestrian channelization. ADA concerns with accessible pedestrian signals are addressed by installing material on the sidewalk pavement along with electronic bells and, in limited cases, pedestrian gates.

Selection criteria for pedestrian crossing safety upgrades have not been specifically developed. However, in situations where rail-highway grade crossings have a pedestrian approach on one or both sides of the crossing an index, called the Texas Priority Index Formula (Figure 4) may be used to select public road crossings for upgrades under the federal section 130 program. The index takes into account six factors: average daily traffic, the number of school buses or special vehicles that use the crossing on a 24 hour period (or any other type of vehicle that is required by law to stop at a railroad crossing, e.g., school bus, transit bus, hazardous material carrier, etc.), the number of trains per day, the maximum timetable speed of the trains, the existing type of warning device in place at the crossing, and the number of auto-train involved collisions in the past 5 year period.

$$PI = V \times SV_f \times T \times (S \times 0.10) \times P_f \times A^{1.15} \times 0.01$$

where:

V = average daily traffic — number of vehicles per day

SV_f = average daily school bus traffic – a factor weighted according to the range of school bus traffic reported as follows:

- 0 buses = 1.00
- 1 - 3 buses = 1.20
- 4 - 10 buses = 1.60
- 11 + buses = 2.0

T = number of trains in a 24-hour period

S = speed — maximum speed of the trains

P_f = protection factor — a factor weighted according to the type of existing traffic control device as follows:

- gates = 0.10
- cantilever flashers = 0.70
- mast flashers = 0.70
- crossbuck, other = 1.00

A = number of auto-train involved crashes in the last five years to the 1.15 power (when $A = 0$ or $A = 1$, then $A = 1$)

EXAMPLE COMPUTATION:

$V = 5000$ v.p.d.

$SV_f = 1.6$ (6 school buses/day)

$T = 12$ trains/day

$S \times 0.10 = 6.0$ ($S = 60$ mph)

$P_f = 0.70$ (mast flashers)

$A = 2.22$ (2 crashes in last five years to the 1.15 power)

$$PI = 5000 (1.6) (12) (6.0) (0.70) (2.22) (0.01)$$

Figure 25. The Texas Priority Index Formula.

The crossings that are candidates for upgrades are then ranked using that priority index formula for a diagnostic study (a template for a final inspection report can be viewed in Appendix B). The department would then obtain or obligate federal funds for each one of those locations to allow not only TxDOT personnel but also railroad personnel to be reimbursed by the USDOT for diagnostic studies.

Using this process the department has addressed the vast majority of safety needs at railroad crossings that are on the state highway system as far as upgrading to flashing light signals and gates. The relevance of this process for pedestrian safety is that the diagnostic inspection team would consider any additional pedestrian safety treatments during the diagnostic inspection. The most typical of such treatment is the electronic bells which are installed at virtually every one of the safety upgrades made at railroad crossings. At some locations, there may be replacing the crossing surface or providing an extended crossing surface to allow better access for pedestrians, if at the diagnostic inspection it is noted that there are walking trails across the tracks. In many locations, typically in urban situations on city streets, there are situations where sidewalks go up to the railroad right of way and pick up on the other side of the railroad right of way. The Federal Section 130 program funds would be used to make safety improvements to eliminate those types of situations, basically extending the sidewalks and adding electronic bells. Additionally, if a particular location has a very high pedestrian traffic the installation of pedestrian gates may be considered. In a typical design the sidewalk or the pathway would go around the backside of the roadway gate. The local government would also be asked to share in the cost for extending sidewalks or pathways.

Regarding engineering standards and guidelines, in addition to the MUTCD, TxDOT also produces a state supplement including warning device guideline sheets that go into plan sets. In a minor deviation from the MUTCD, the emergency notification signs are different in part 8 of the Texas manual. This is because a relevant 1979 state law requiring the state to place emergency notification signs on railroad crossing warning devices preceded the Federal Railroad Safety Act of 2008 which was the first federal legislation that required railroad companies to post those emergency notification signs on railroad crossings. In particular, while state emergency notification signs have a white background with black lettering, the MUTCD requires those signs to have a blue background with white lettering. In addition, the state follows any applicable AREMA guideline for the design or placement of railroad crossing warning devices.

Regarding trespassing problems TxDOT considers it be more of a local issue between the railroad and a particular municipality. This is because in most areas the railroad right of way is open and does not have controlled access. The department is represented in the Texas Operation Lifesaver (OL) organization and supports the railroad companies and the Texas OL in their efforts. In particular, TxDOT has assisted in helping the Texas OL obtain federal safety 402 grants for public education material, campaigns and programs. Such an example includes a pocket guide for law enforcement officials that outlines all the existing state or federal laws that could be enforced to prevent railroad crossing violations, and also encourage the enforcement of trespassing violations (<http://www.tslb.org/>). This information is distributed to police departments and police academies throughout the state.

As of 2010 the state annual program is \$15 million per year for federal section 130 projects (the largest share in the nation). The vast majority is allocated to rail-highway crossings, but pedestrian treatment as described above are covered although there is no separate tracking for them. An additional annual \$3.5 million state funded program (it provides reimbursement to the railroad company for replacing worn out crossing surfaces for crossings on the state highway system (about 50 crossing per year). Finally, another state funded program is the state signal maintenance program and that program is funded at 1.1 million per year and it assists railroad companies in offsetting the cost of maintaining active warning devices at all crossings on the state highway system.

Utah

In Utah, the Utah Transit Authority (UTA) operates both light-rail and commuter-rail and the vast majority of the crossings are at grade level. The agency is embarking in a campaign to improve the safety at those crossings. The effort is supported mostly by local funds in the beginning while other type of funding will be sought later as needed.

All the crossings have tactile strips on both sides of the crossing for ADA purposes. Existing safety equipment for non-motorized users includes signs, on and off channelizing fencing to station platforms, so that pedestrians face the oncoming train when they are crossing the tracks. All of the newer crossings have pedestrian gates in front of the sidewalks, but several of the older crossings do have the gates behind the sidewalks.



A few locations are equipped with swing gates. These gates actually swing on both directions, towards the tracks and away from the tracks, and serve to guide pedestrians toward the track and as a reminder to look when they're crossing the tracks. The swing gates are coupled with static signs attached containing the approaching train symbol with arrows below it. Active signage includes the MUTCD Light Rail Transit Approaching-Activated Blank-Out Warning Sign (W10-7) – see picture to the left – coupled with an electronic bell. In a few locations on commuter rail crossings, there are some solar-powered LED signs

similar to a W10-7 sign.

In the downtown area there are a number of pedestrian-only crossings. Some of them are signalized and some of them are not. When there are no trains or cars the signals serve the crossing pedestrians (no push buttons). In the presence of a train or a car the green light for a car and the 'proceed' signal for the train appear. These crossings are relatively low-speed crossings, 25 miles per hour or less.

Interestingly, of those crosswalks the unsignalized ones have been found to be safer than the signalized crosswalks (in the last 3.5 years of observation). A possible explanation is that people tend to pay more attention to an unsignalized crossing. With active signage present, pedestrians, drivers, and train operators may rely solely on the signage.

Trespassing is not a major problem yet and enforcement is coordinated with the transit police force. A limited number of cameras at station locations (that happen to be at the crossing locations most of the time) further assist the effort of monitoring trespassing activity. In addition, the transit authority participates in Operation Lifesaver activities that cover all the schools in the corridor of operations. In addition, they have held safety open houses for parents of kids at schools close to the corridor to make them aware of the trains, the frequency and the speed of the trains and general safety information. They have also used billboard campaigns and safety advertisements targeting crossings specifically and safety at crossings to either warn people of new service or remind them of safety. Addressing trespassing has received additional attention in some problematic cases where signage and non-climbable fencing has been installed.

The transit agency has additionally explored ways that could warn non-motorist users of grade crossings who are distracted by being on the phone, texting, listening to music, wearing clothing that restricts their line of sight, or other factors that may interfere with seeing an oncoming train, especially in a quiet zone setting. It seems that channelizing fencing and swing gates assist in this regard. What appears to be missing, however, is a methodology to assist with proper risk management for non-motorized users at grade crossings. Quiet zones, for example, satisfy the required criteria for motorists, but may not do the same for pedestrians. Forcing bicyclists off their bicycles before crossing may also benefit this group of users at grade crossings.

Virginia

The Virginia Department of Transportation (VDOT) is responsible for providing possible funding to any public crossing owner, whether it be railroad companies, urban localities, military or private corporations that own a public highway-rail crossing. The annual rail safety program is project proposal / application based for funding requests. Each applicant / project safety partner is required to provide supporting analysis with their proposal. Each proposal is evaluated on a case by case basis and funds are allocated based on need. Fifty percent of the funds provided have to be used for the upgrade / installation of automatic warning devices. Signing and pavement marking outside of railroad right-of-way has typically been the responsibility of the public authority maintaining the roadway. Since 2004 there have been about five requests for pedestrian gates or signing warranted. Many times the local authorities handled these issues directly with the railroad companies and notify VDOT if these upgrades / changes occur.

VDOT is not responsible for education, enforcement or outreach programs concerning pedestrians at rail crossings. In Virginia, the Virginia Department of Motor Vehicles and Virginia Operation Lifesaver (<http://www.va-ol.org/contact.html>) have handled these tasks. State code referencing public highway-rail crossings does exist but none exclusive to pedestrians.

West Virginia

The state does not track exclusive pedestrian crossings and safety improvements in pedestrian approaches to rail-highway grade crossings may be planned only if the crossings are scheduled for safety upgrades. Although costs for such upgrades are not typically itemized or available for each crossing, it is estimated that accessible traffic signals and detectable warnings would cost 12 to 15 thousand dollars per intersection.

Cost-effectiveness considerations in cases with upgrading safety improvements to meet ADA guidelines are never an issue. The unusual attention to the needs of this particular group is due to the fact that the state may have the highest percentage of people with disabilities in the country because of industry (e.g., mining, logging, etc.), topography and difficulty in getting good medical care, as well as the highest percentage of soldiers and airmen of any state in the country in wartimes. About 27 percent of the general population is estimated to have a disability of some kind while the national average is about 17 percent.

There is no prioritization of safety improvements. Decisions are made on a crossing-by-crossing case based on the input provided by a diagnostic team regarding operations, preemption interconnection, and track circuitry control. Being an energy producing state (e.g., coal, natural gas, geothermal energy), many signals installed in the 70s are now in need of updating. The increase of vehicular traffic at crossings (because of energy production activities) requires that those crossings be scheduled for safety upgrades.

The issue with trespassing at grade crossings or in general in the railroad right of way is a serious one in the state. It is very difficult to officially distinguish between intentional and unintentional trespassing in pedestrian fatal accidents. Moreover, it was here that trespassing received a lot of attention in the local chapter of the Operation Lifesaver before becoming an issue for the national organization. Obviously, the presence of the local chapter remains very strong in the state with presentations and training for emergency responders and training for police officers to investigate crossing accidents.

The state DOT is also involved in the activities of the local chapter. An example of these types of activities is a tradition established at a high school in Kanawha County that is near a railroad yard with 16 tracks in it. Before the high school opens every year, arrangements are made so that and every student entering that high school at any grade level, as part of their orientation, attends an Operation Lifesaver presentation.

The intensity of enforcement campaigns varies. Enforcement is shared by the police and the railroads while the state distributes information about trespassing activity and problem spots. The practice is to issue a warning and enter the incident into a database the first time. The second time offenders are required to appear before a magistrate.

The state is 'stretching' its federal budget for safety at crossings (about \$2 million per year) by having the railroads contributing to the maximum of their requirement while the state covers additional expenses necessary to bring safety improvements to necessary standards. For example, the crossing surface from the outer end of the tie to the outer end of the tie is the responsibility of the railroad. If the railroad installs a crossing surface suitable for lighter-load traffic, the state will pay the difference to upgrade the surface to a standard surface suitable for heavy load-load traffic (in this case about \$10 to \$12 thousand per crossing).

Wisconsin

In Wisconsin, the Office of the Commissioner of Railroads has jurisdiction over public rail crossings. The great majority are rail-highway grade crossings and only a few are dedicated pedestrian crossings. Passive warning devices are mostly used. There was a fairly recent upgrade in all pedestrian crossings with new reflective crossbucks and strips on the front and back of the post. Detectable signals are not usually deployed because the ADA guidelines are not clear regarding their use for pedestrian rail crossings (the federal government has not adopted the ADA guidelines for pedestrian crossings yet). Although the railroads like using channelizing devices the commission is not a big fan because of maintenance costs.

Occasionally, automatic flashing lights have been installed in pedestrian crossings that are not associated with a roadway. Pedestrian gates are a concern because of perceptions with safety issues, e.g., somebody in a wheel chair getting trapped in the track zone when the gate is coming down. Elsewhere, in pedestrian crossings adjacent to rail-highway crossings when automatic signals for the motorists are installed an effort is made to also install bells on the side that is nearer to the non-motorist pathway.

A number of criteria, in an ad hoc fashion (compared to a more detailed methodology for rail-highway crossings), is used when selecting safety treatments for pedestrian crossings including: number of trains and maximum train operating speed (main factors), as well as peak hour pedestrian usage, sight obstruction by immovable objects (e.g., buildings), and grades on the approaches to the crossing (although this can be adjusted so they are not excessive). Wisconsin applies, in addition to the MUTCD and AASHTO guidelines, its own design guidelines for rail crossings utilized by non-motorized users (<http://www.dot.wisconsin.gov/business/engrserv/docs/wmutcd.pdf>)

Providing a safe crossing serves the additional function of discouraging trespassing. However, jurisdiction about trespassing lies with the railroads and the state commission does not evaluate the effectiveness of countermeasures.

Wyoming

In the state of Wyoming there are only four pedestrian-rail crossings, and they are all grade separated.

Industry Experts

Expert #1

Expert #1 has had almost 25 years of experience within the traffic signal industry in terms of design, operations and maintenance. He is currently serving in the Railroad and Light Rail Technical Committee for the National Committee on Uniform Traffic Control Devices (NCUTCD), the official industry liaison group to Federal Highway Administration that does a lot of the proposed revisions and upgrades to MUTCD. The technical committee meets face-to-face twice per year and has a few task groups underway, one of which is the Pedestrian Traffic Control Devices at Grade Crossings task group.

The task group is working on substantial changes to the national MUTCD in regards to pedestrian devices because they recognize that this area has yet to receive significant attention over the years. As a result, they have developed substantial draft language that has been sent out for sponsor comments, and is currently under review.

Expert #1 also serves with AREMA Committee 36, which is the Highway Rail Grade Crossing within AREMA, and in particular in the Subcommittee on Controls that is responsible for all of the technical requirements for operation of warning devices. According to Expert #1 it would be fair to suggest that the AREMA *Communication and Signal Manual* (<http://www.arema.org/publications/cs/index.aspx>) is to the railroad industry what MUTCD is to traffic engineers.

Expert #1 is also working with the Institute of Transportation Engineers (ITE) to produce another update to the ITE Recommended Practice on Preemption of Traffic Signals at Grade Crossings (http://www.ite.org/standards/Update_TENC10.pdf), as well as an update to the Grade Crossing Handbook (<http://www.ite.org/decade/pubs/TB-019-E.pdf>). Expert #1 is also involved with the American Public Transportation Association (APTA) in regard to the standards for grade crossing warning systems.

Expert #1's involvement with such different top-tier organizations provides opportunities to work within a number of different engineering groups and impact events that make sure that standards and recommended practices are in agreement with one another. As a result, nationally, there is probably more agreement and cohesiveness amongst these different documents than it has ever been in the past. For example, the definition of advance preemption in MUTCD looks the same as the one in AREMA and ITE documents as well as in APTA standards. Another example is the aforementioned NCUTCD document in preparation for the next MUTCD update. This additional information will expand the next MUTCD edition to include sidewalks at grade crossings, which is a different issue from a pathway grade crossing first introduced in Part 8 of the 2009 MUTCD.

In this regard, Expert #1 discussed two examples of relevance. The first is the Metrolink "Manual". The commuter rail operator in Southern California has published standards for different types of treatments in the "Highway-Rail Grade Crossings Recommended Design Practices and Standards Manual" (http://mobile.usablenet.com/mt/www.metrolinktrains.com/pub_projects/?id=11). The relevant sections from the manual have been highlighted in the literature chapter.

The second is a very detailed design of a crossing system on Metrolink at a location called Flower Street (http://www.fra.dot.gov/downloads/Research/3_3DanGuerrero_MetrolinkPedestrianTreatment.pdf) in Glendale, California. This case is interesting because it involved a new crossing (it is rare these days to establish new crossings on rail lines that aren't grade separated). The Flower Street crossing incorporates pedestrian gates in addition to all the traffic control devices for the vehicular warning system but it also incorporates fencing and swing-gates to improve

effectiveness (the use of pedestrian gates without fencing has been found rather ineffective as documented in the literature chapter).

The larger railroads usually will do the electrical design for the operation, the installation and then the ongoing maintenance of the warning devices at rail grade crossings. The short line railroads and the commuter railroads have varying policies. Some of them use a 'continuing contractor' who provides those services on an ongoing basis in accordance with the federal acquisition regulations (see <http://www.dot.gov/ost/m60/tamtar/tarcomplete.htm>); others elect to use a competitive bid process on a project-by-project basis. Others use their own in-house forces to do the work.

Selecting an appropriate mix of treatments for each rail grade crossing requires convening a diagnostic team that would generally consist of representatives from the Highway Authority, a regulatory authority (e.g., the Illinois Commerce Commission or the Public Utilities Commission in California or Ohio) – if there is one. Not all states have regulatory authorities; in Texas, for example, it would be the Texas Department of Transportation. Those individuals are the 'public agency'. In addition, representatives from the railroad and then additional representatives from other parties of interest would participate depending on the occasion. For example, if a crossing involved a lot of children that walked to a school nearby the crossing, representatives from the school may be involved in the diagnostic team; or in a situation where only a number of school buses were using the crossing, a safety person that is in charge of the school bus operation may be involved; or in another example, a situation with a crossing that had a significant number of hazardous material hauling vehicles from a specific facility may require the involvement of individuals from that facility. Therefore, a diagnostic team membership can vary based on the site-specific needs of the crossing, but once the diagnostic team is convened and meets then they are considered the experts to make the determination of the traffic control devices to be employed at a given location.

The diagnostic team makes the recommendation for the different devices and as a general rule, the public agency then takes the diagnostic team recommendations and then they will progress the project, but the diagnostic team by law has some specific immunities from liability in terms of determination of devices. This is why it is very critical that the diagnostic team process be followed in order to make sure that those protections are maintained through the process to determine the appropriate traffic control devices.

During the deliberations of the diagnostic team cost considerations are always an issue, but safety remains the number one issue. It is possible that the costs and effectiveness of different types of treatments may be considered as part of the process, especially if there are two or three options to pursue, but, as a general rule, costs will remain of lower priority compared to safety. In Expert #1's words, *"... when the diagnostic team is convened there is probably some general understanding what the goals are. For example, we know that the best grade crossing is a crossing that doesn't exist since if there is no crossing then we don't have risk. The next best crossing is a grade-separated crossing where we eliminate the potential for conflict, but we also understand that in many cases there's the opportunity for people to violate. So, they may willfully choose to avoid the separation; if it involves climbing up some structure for a walkway to go across the tracks, it's easier to run across the tracks and then those devices have to be considered in conjunction with compliance measures like fencing. From there, we fall down into an at-grade crossing. What type of traffic control system would be appropriate, considering the fact that it will remain at-grade?"*

In this regard, it would not be farfetched to assume that although there is not a formal cost-effectiveness evaluation process in place, in practice, the process happens as a consensus-building exercise among the diagnostic team members. In fact, it is not often possible to get a good determination of cost until the diagnostic team completes its work. For example, if the diagnostic team determines that the crossing surface over the track area is extended to accommodate a wider sidewalk an additional cost could be widening the sidewalk

to provide ADA accessibility, markings, etc. before even beginning to consider traffic control devices.

This is the information that a diagnostic team does not have access to in advance. It requires that a set of plans be prepared at least to the level of detail that cost proposals could be solicited for that kind of construction work and then the railroad would begin to prepare a cost estimate for any active warning devices and changes, plus any changes necessary to the track structure, such as extending the crossing surface itself.

Regarding factors relevant for choosing warning devices, collision experience would typically be considered, in addition to train speeds and number of trains, as well as sight distance and adjacency of multiple crossings. With regard to crossing prioritization formula there is not a national standard and it is done on a state-by-state basis using their own formulas. The focus of those formulas is mostly for vehicular rail-highway crossings and pedestrians are not usually part of the equation, but they are implicitly considered especially in those places that have sidewalks attached to the highway.

Another issue the states have started looking at is the age of existing warning devices. A lot of the crossings in locations with the (formula-based) highest potential risk have probably received active warning devices many, many years ago, and a lot of those devices have reached, or probably exceeded, the end of their useful life. Since the time of the initial installation a lot of environmental factors have changed including higher vehicular volumes and possibly higher pedestrian volumes in crossing locations that have some of the oldest train-detection circuitry. The question then becomes whether it is preferable to update older warning devices rather than install a warning system at a crossing that does not have active devices but also has a very low vehicular or very low pedestrian traffic.

Regarding trespassing, Expert #1 spoke from a first-hand experience as a law enforcement officer and observed that when new law-enforcement officers go through their initial training, they effectively get no information at all about grade crossings, grade crossing safety, and trespassing. In addition, there is a need to educate the courts and prosecutors to be able to understand the significance of trespassing and understand that it is a crime. Moreover, a lot of people do not consider walking down the railroad tracks as trespassing. They tend to view it as a public right-of-way and a lot of them have grown up with a bad practice of playing on a railroad track or being on the tracks. According to Expert #1, the only way this problem is going to be solved is through education of prosecutors and judges to recognize it is an issue.

Expert #1 agreed with other survey participants about the value of local advocacy regarding enforcement activities for trespassing mitigation, especially in times of scarce resources. Additionally, the railroad police could also serve as a liaison between the railroad and local law enforcement. For example, one railroad police officer might be able to deal with one crossing a day, but he/she would be more effective if they coordinate with half a dozen local police agencies and encourage their active participation.

Expert #2, Operation Lifesaver

The state "chapters" of the Operation Lifesaver (OL) organization are mostly funded by a combination of state and railroad resources that varies by state. Similarly, the level of staff interaction between state and OL also varies by state. For example, the person who operates with OL in that state may be an employee of that state Department of Transportation working partly with that DOT and partly with OL. In some instances, with funding from the Federal Transit Administration (because of light rail and street car operations) the OL works with local transit agencies to help with the growing problem involving pedestrian conflicts.

The state OL agencies are not exactly chapters but they are under the umbrella of the main OL organization headquartered in Washington, D.C., and receive, at the present time, annual funding of \$1,500. Operation Lifesaver provides a payroll system for the state OL

agencies (usually operating with a staff of one person). The national organization provides to the state OL agencies educational programs, such as videos and other materials used in outreach activities, talk to students or truck drivers or school bus drivers, for example. The national organization also provides assistance regarding the start-up of a website. Otherwise, the state OL agencies run independently within their state under the direction of their own board of directors.

Mitigating trespassing need not be that expensive in some cases. Landscaping, such as a prickly bush, in the right place (e.g., at the entrance to certain trestles) at the right time, could make a difference. In other places video monitoring can make a difference. Obviously, enforcement could play a major role, but there are not enough law enforcement officers because many communities are having financial difficulties.

It would be helpful if the railroads could follow the practice in Europe and make available to OL archived video of train operations (video that is no longer involved in litigation, say, five years old) so that the public can be convinced, for example, that there is no room to lie under a train (in the U.S.) as the train passes over with lethal implications. Another suggestion would be to publicize trespassing 'hot spots'. Some of the major (Class I) railroads are in the process of formalizing the reporting of close-call situations by field personnel (as in the U.K.). If it becomes common knowledge that a limited number of locations experience unusual number of suicides certain types of intervention may prove to be more effective. This is the reason why the railroad, the DOT and the local communities would need to work together with OL in those situations. After all, trespassing occurs much more frequently away from crossings and communities become faster aware of the problem.

In 2003, the OL has issued a draft "Community Trespass Prevention Guide" that was published in its final form under the title "Trespassing on Railway Lines – A Community Problem-Solving Guide" by the Direction 2006 partnership in Canada (2006). The Community Trespass Prevention Program incorporates a problem-solving model designed to provide a step-by-step approach for dealing with trespassing issues in communities. Development of this program and its supporting materials is based on actual community problem solving projects. The Volpe Center used the guide developed as a baseline strategy to initiate a three-year research project, which started in July 2009. The methodology is centered on working with the South Florida Regional Transportation Authority (SFRTA) stakeholder partnership to demonstrate potential benefits, including documenting best practices and lessons learned, of implementation and evaluation of trespass prevention strategies on the rail network in West Palm Beach, Florida and all of its rights-of-way.

With regard to funding issues, there is a concern about whether Section 130 funding would continue in its current form or diverted to non-rail-safety-related projects. The FRA that has the willingness and expertise with rail safety issues does not have leverage over dispersing this type of funding.

Expert #3

Expert #3, a forty-year veteran in the railroad industry, raised the issue of risk management at grade crossings right away arguing about the need to differentiate between the trespassers along the line of route and those pedestrians using the local crossing properly or improperly. This is in addition to separating accidents from suicides because the means for managing accidental death and intended death are different. One of the weaknesses in the United States, according to Expert #3, is that we don't consistently and coherently account and report for the suicides that take place along the railway but, rather, lump them in with trespassers, if at all. It would be equally important to distinguish among three classes of grade crossings: (a) grade crossings on the public highway, which are used by pedestrians; (b) hybrid

crossings with public footpath rights, but private vehicular rights; and (c) public footpaths (the number of private footpaths is probably comparably too small).

In addition, to distinguishing among crossings, correctly recording the different types of non-motorized users (e.g., pedestrians, cyclists, and mobility impaired persons on mobility scooters) is also important for managing risk. Other types of users, for example, equestrians and adults pushing strollers on public footpaths, provide additional user categories that would complicate a data collection program.

Once a detailed classification of crossings and users is done, one can start contemplating about addressing issues for particular crossing- and user-type combination. For example, if we start at the public highway grade crossing, increasingly, the sidewalks have tactile markings on them to help people who are blind that are faced with a grade crossing. This type of treatment would be sufficient when there is a barrier on the same side of the road as the sidewalk because there is a significant pedestrian risk on public highway grade crossings that, for the most part, are automated vis-à-vis being staffed or under human surveillance. The latter types of crossings have, obviously, a safety performance that is a magnitude greater than the automatic half barrier level crossings.

Subsequently, a risk manager would look into the standard controls, i.e., the lights, the audible warnings, the signage, and at those crossings with a half barrier (a single arm on each side of the road, which blocks only oncoming traffic). At a small number of footpath crossings, there are miniature warning lights that show red or green indicating whether it is safe to cross and they can also be provided at pedestrian crossings at stations. There is an issue in the U.K. around those crossings on multiple track lines as to the nature of a second train warning. Historically, practice has been to have the audible alert and the red light to continue to show, but there is no change in the tone of the warning, and it relies on the vigilance of the people using the crossing to conclude that there is a second train approaching. The interest can then shift to how to communicate the warning of a second train coming.

The basic premise of the footpath level crossing is that there will be signs warning of the presence of trains and it is incumbent on the user to look out for themselves. Most of the footpath level crossings without any additional protection are in rural areas and most of them are used recreationally. In the urban context there are more sophisticated pedestrian crossings, often (in the U.K.) with a chicane to prevent cyclist from blowing strait through the crossing without stopping.

Chicanes can also be used to cause people to look both ways before crossing. The practice in the U.K. is to provide enough time for users to do that. An additional five seconds is then allowed to account for their decision making process. Normally, a minimum of twenty seconds is provided. If, for any reason, this cannot be achieved, trains are required to sound the train horn. If there is evidence of a substantial use of a crossing by impaired users, say, a crossing regularly used by old people, or used by people with wheel barrels to access their vegetable patch or allotment, there would be an increase in the time by fifty percent. However, the decision time is still left at five seconds. Finally, the time needed to cross by two meters (6' and 6.74") before the railway line, and two meters after the railway line. Obviously, the crossing time will vary depending on the crossing configuration (e.g., single, double or triple track, with/without an island in between, etc.).

Therefore, a minimum time of 20 seconds (assuming an able-bodied walking speed of 1.2 m/sec or 3.9 ft/sec) would account for 15 second crossing time plus the 5 second decision time. In a situation that requires a 17 second crossing time adding the 5 seconds would bring the minimum time up to 22 seconds. In addition, in the presence of vulnerable users of that grade crossing a 50 percent increase of the crossing time could further raise the minimum time to 33 seconds. Again, if the minimum of 20 seconds cannot be provided, it is customary to require all trains to sound their horn on the approach to the crossing.

An important feature in the safety calculus would be the crossing surface treatment. Increasingly, non-slip crossing surfaces are provided. In cases of a very long way between elements of the same railway or two railways side by side, it is practical to create a refuge. In this case, the time for decision making above and the crossing time should be treated separately.

Turning the attention to the characteristics of pedestrian fatalities, in Britain, one group of people with a disproportionate number of casualties are people with dogs. The dogs often lead and they become startled by the presence of the train and the owner's instinct is to follow the dog. There have been a number of fatalities in recent years where sane people have reacted to the behavior of their dog at the expense of their own lives. Therefore, this would be another factor to consider when assessing the risk.

Another group that is overrepresented is people aged over seventy as a function of their slower decision making process, and in some cases, reduced mobility skills. In addition to those cases, another component of accidental deaths is people who deliberately try to beat the train ignoring the lowered barriers (for the motorists).

With regard to the cost effectiveness of safety treatments, Expert #3 said that in the U.K. there is a long prescriptive approach in that the duty on a railway, or the infrastructure provider, is to manage risk so far as it is reasonably practical. The U.K. Department of Transportation publishes for the guidance of those considering highway schemes an annual figure for the value of preventing a fatality that they are to use in the highway calculations. That same figure is used by the railways and every year, the Rail Safety and Standards Board (RSSB) publishes the updated figure that people are expected to use in their risk assessments.

Network Rail which has the vast majority of grade crossings in the U.K. uses the All Level Crossing Risk Model (ALCRM) to conduct essentially an initial assessment of the risk at the individual crossing, relative to the population of grade crossings as a whole on Network Rail. Then an outcome process essentially prioritizes relative to others, the crossings at which the need to consider additional measures can be justified. The process encompasses both rail-highway and pedestrian crossings.

Regarding the selection criteria for warning devices, Expert #3 asks, first, whether the particular crossing under consideration may be closed or consolidated with neighboring crossings. Then the process would examine the cost of various safety treatment options available versus the expected benefits. In most cases with pedestrian crossings, the risk level would not justify (based on the value of life saved) active controls. This is how Expert #3 described the evaluation process *"... when you have an understanding of the individual and the collective risk arising at any individual level crossing, what you then do, at a particular level crossing, is a process of optioneering, which is: What could I do to address this risk? Can I close the level crossing? What can I do in the way of upgrade of this level crossing? Are the issues related with the condition of the walkway of the level crossing? Are they related with sighting at the level crossing? Are they a function of a large number of or a regular number of, say, a group of school children going to a nearby primary school or elementary school? And you therefore look at the nature of the user of the level crossing and the controls that might be effective.*

So, for example, you might consider putting in a chicane that causes people to look both ways as they come to make a decision to cross. You might identify the warnings signage as appropriate. And you go through, essentially, a shopping list, which is as long as the options you have. And then that were to include, in theory, is it practical to provide active controls at this level crossing? And what that does do, is focus you on particular classes of level crossings. And you may find that crossings with lights and audible alarms and signage but no barriers may have a disproportionate contribution of risk; so what you're at is the upgrade root that would take you typically to an automatic half barrier solution. What that is doing is focusing you on the catastrophic risk, i.e., the risk of stopping a vehicle from derailing the train rather than the

pedestrian risk. And that's a function that those crossings seem to have heavier vehicle use and pedestrian use.

And if you got in an urban context where you can't close the crossings, you might better manage the risk by providing a foot bridge for the able-bodied people, but you don't provide elevators to get the mobility impaired up to the higher levels to cross the railway because the cost of the lifts are disproportionate to the benefit given that, once the train has passed, they can cross at grade.

So, you have to look at what you have to do for the disabled, alongside what you can practically do for the able bodied without providing the cost of ramp access or providing lifts. Now to close level crossings, you have to provide the ramps or the lifts. But if you keep the level crossing for vehicular traffic, but essentially manage the risk of people not being prepared to wait for the train giving them the option of going over the bridge."

Once the ALCRM process has been completed the principle infrastructure manager (in Network Rail) has an active consideration process triggered by a particular risk score. There is also a fallback plan to allow for consideration of a recent accident or a history of near misses or near hits at a particular grade crossing, or that the signs remain in place, that the sighting distances remain open and are not obstructed by vegetation. Then the ALCRM process begins anew. This feedback option makes the entire process very robust.

Regarding outreach educational activities in the U.K., Expert #3 said that Network Rail runs a program called "No Messing" which essentially uses diversionary activities in problematic locations. In addition, there are numbers of trained operators to do good work and perhaps focus on grade crossings at the stations they serve. The outreach also includes a series of prefaced and vivid visual video and radio-based advertisement under the "Don't Run the Risk" campaign, which, essentially, tries to get across the message that grade crossings are life savers, not time wasters.

Expert #3 continued by offering a five-point program of risk management to increase safety at pedestrian (and vehicular) rail grade crossings. More specifically, he pointed to the five 'Es' ('Engineering', 'Education', 'Enforcement', 'Enabling' and 'Evaluation'). The first three 'Es' have been key underlying principles of Operation Lifesaver in the USA. 'Enabling' was added during the formation in Britain of the National Level Crossing Safety Group (NLXSG) in 2002, and is concerned with providing resources, people and systems to facilitate progress with improving level crossing safety (Little, 2007). 'Evaluation' was added more recently, and has become of particular interest in Europe where attention is being paid to developing common reporting methods for level crossings (i.e. types of crossings, numbers and risk measurement), and being able to measure the effectiveness of programs.

Little (2007a) defined these five 'Es' as follows:

- Enabling: The provision of resources through people, procedures, and systems to allow the other 'Es' to be effective.
- Education: Increasing public awareness of the dangers of crossings and educating pedestrians, road vehicle drivers and other users how to use them correctly.
- Engineering: The protection fitted to level crossings through lights, horns, barriers, telephones and signs together with research into innovative means of increasing safety.
- Enforcement: The use of laws to prosecute those who endanger themselves or others by misuse of crossings.
- Evaluation: The idea as envisaged by the NLXSG is to encourage organizations to set a baseline before embarking on new initiatives so that the before and after can be properly compared.

Expert #3 argued that a process that starts with 'Evaluation', first, and then proceeds to 'Enabling', 'Engineering', 'Education', 'Enforcement', and then re-evaluates under another 'Evaluation' step could help efforts to raise safety outcomes for pedestrians at rail grade crossings, and, essentially, optimizes the risk management at grade crossings. Emphasis would be on 'Enabling' because it would not be possible to optimize risk management without a framework that causes railway and highway to work together. For example, in Britain, until about six or seven years ago, grade crossings were seen solely as a railway problem. In recent years, there has been an effort to increase local partnerships where the rail and highway authorities are both principal players. Such arrangements are not as formalized as in Australia where in some states it is required that there is an interface agreement between highway and rail authority.

The other dimension in an enabling framework is the interaction between risk management and decision making about planning. For example, does changing the land use in the vicinity of a crossing, say, because of zoning changes, increase the risk? If it does, what should the developer contribute toward controlling the risk? There is a need, therefore, to have to involve the public foot paths and the right of way regulated by the local authority and the planning department.

When it comes to cost sharing, the obligation to provide network controls at a grade crossing essentially lies with the railway. However, actual implementation has to happen in conjunction with the planning authority. As new developments happen the highway authority ought to be involved because the advance warning signs are sited on the highway. Moreover, the highway authority would have a role in providing the paved sidewalks to the barrier up to the grade crossing. Once an assessment is made about what the risk is and what the controls are, then an agreement can be reached regarding who pays what.

An important point was made by Expert #3 in regard to location misclassification in accidents involving trespassers. A significant advantage in the United States is that most of the Class I railroads have hidden cameras, allowing thereby to identify where incidents take place (although the information is not made available through regular channels). In use in the U.K. is an industry wide instant reporting system called Safety Management Information System (SMIS). The system manages reports from train operators (in the Network Rail system) and each reported event has an owner. More information about the system is given in the web link below.

Expert #3 believes that the public database maintained by the FRA is intellectually flawed. This is because of the high degree of focus on collisions between trains and vehicles. It is likely, as a result, to encounter situations in which pedestrian accidents and fatalities are misclassified as trespassing incidents. This is because of a mindset that considers pedestrian incidents as trespassing incidents failing to account for the possibility that because a public crossing is essentially a public space where people can cross, in certain cases users may have erred in judgment or misused the crossing.

Expert #3, finally, suggested the following websites as a good source of information:

- The Great Britain's national rail system's Safety Management Information System: <http://www.rssb.co.uk/SPR/Pages/SMIS.aspx>
- The most recent annual safety performance report for the Great Britain's national rail system: <http://www.rssb.co.uk/SPR/REPORTS/Pages/default.aspx>. Of particular relevance is the road-rail interface section and Appendix E. Of additional interest is the coverage of suicide (including Appendix D) and the broader risk profile applicable to the UK rail system.
- www.rssb.co.uk/SiteCollectionDocuments/pdf/reports/Research/T907_guide_final.pdf for a guide to research concerning the road-rail interface undertaken by the Rail Safety and Standards Board

- www.networkrail.co.uk/asp/2292.aspx. This is (UK's) Network Rail's guide to using level crossings safely. Details of Network Rail's "no-messin" safety education program and other Network Rail resources can be found by scrolling down to the bottom right of the above webpage.
- Policy and guidance published by the Office of Rail Regulation (the safety and economic regulator for railways in Great Britain) as it relates to level crossings can be found at: <http://www.rail-reg.gov.uk/server/show/nav.1134>.
- The Rail Accident Investigation Branch, the independent accident investigation body for the United Kingdom has investigated a number of level crossing accidents. Their investigation reports can be found at www.raib.gov.uk/publications/investigation_reports.cfm. It would also be worthwhile reading www.raib.gov.uk/latest_news/news_archive/news_archive_2006/061211_pn_elsenham.cfm and www.raib.gov.uk/latest_news/news_archive/news_archive_2009/091119_pn_bayles_wylies.cfm.

Expert #4

Expert #4's initial involvement with pedestrian crossings came as a result of participation in the preparation of the TCRP Report 17 (Korve et al., 1996), which was the one entitled "Integration of Light Rail Transit into City Streets". Expert #4 was also involved in the study "Light Rail Service: Pedestrian and Vehicular Safety" published in TCRP Report 69 (Korve et al., 2001). Expert #4 has been involved in the design of traffic features for light rail projects around the country, and is on the railroad technical committee for the National Committee on Uniform Traffic Control Devices (NCUTCD), which makes the recommendations for crossing traffic treatments.

Expert #4 suggested that one of the difficulties about cost information of installed warning devices is that the actual costs change as they move from the planning stage, to the design stage, to the design & build stage. For example, in the case of a light-rail crossing that's on the street, the curb and the handicap ramps are going to be installed under the civil contract; then there will be a separate contract for the traffic signal vendor, the traffic signal poles and push-buttons and lights; and then another a separate contract with a railroad signal vendor to provide railroad equipment. It appears that the actual installation of these systems is done by different professional discipline at each stage. As a rule of thumb, the cost of construction doubles the cost of the component. Moreover, information about such costs would more likely be available for projects involving safety upgrades vis-à-vis new crossing projects.

Cost is not normally one of the criteria that determine the selection of safety devices at crossings. The first question that is usually being asked is whether there is a need for a grade separation. Grade separation would consume the bulk of the budget compared to the cost of additional safety devices needed. If a decision is made against grade separation, again, cost is not a factor since the concern remains to install whatever system is appropriate for the situation to ascertain safety. In addition, available cost-effectiveness methodologies determine the priority of addressing the problem at one location versus another (by estimating the number of people that are benefited versus the cost of the total treatment), but they are not used to select the individual components of the safety treatment.

In new crossing situations, the decision-making public authority (say, a Utility Commission) determines the type of safety equipment that need to be installed after agreement with a field diagnostic team. Then a funding allocation is made in order for the project to move forward.

In situations involving safety upgrades to an existing crossing, the main concern is that the upgrades be legally defensible. A striping upgrade, for example, is considered under the presumption that the cost is fairly minor, and also under the presumption that if the signing and striping is not up to current standards, then there may be a large legal exposure. Subsequent considerations might be about upgrading from passive to active devices, or about upgrading the active devices. It is generally known that most of the problems with grade crossing collisions occur at locations where there is an interconnect with a traffic signal where the equipment has not been kept up-to-date, and so it cannot provide all the features; one of the most important features that needs to be provided in many cases is the advanced preemption.

Advanced preemption was a critical factor behind the dramatic collision in Fox River Grove, Illinois in the 1990s. This is because a traffic signal adjacent to a grade crossing may require more time to channelize the traffic in the right mode prior to the activation of the crossing gates than is provided by the current rail signaling regime. You would need then to extend the warning times with advanced warning which interferes with rail operations because you are extending the signal distances, the distances that are covered by the signaling system for thousands of feet. Such upgrades would cost the railroad millions of dollars. Moreover, in order to make use of that information, the traffic controller would need to be replaced incurring thereby additional costs. In the end, the situation calls for replacing virtually everything at the crossing to barely meet current standards. Although this discussion is relevant for the particular rail-highway grade crossing it illustrates how advanced pre-emption can drive up costs to safeguard against the biggest possible consequence. If we would have to only consider bicycle and pedestrian devices in a similar situation, it would be a lot easier to provide because the warning times required are generally shorter.

Addressing trespassing, according to Expert #4, could start by providing a good (convenient) way for pedestrians to cross. In addition, strategic placement (e.g., within a certain feet distance of the road crossing, or in the vicinity of a station) of effective types of fencing (e.g., a chain-link fence that is a non-climbable because the vertical pieces of wire fabric are too close together to stick a shoe in and climb it) would deter or at least make it more difficult for trespassers to go through. Some relevant low-tech treatments would include landscaping with cactuses and rose bushes.

Interestingly, a common behavior with trespassing is that pedestrians look down the track and decide they can cross before the train gets there even though the warning device has been activated. Another type of trespasser warrants perhaps more attention because they don't realize they have walked into a crossing (compared to the other type of trespassers that shows certain decision-making ability, even if the wrong judgment).

Expert #5

Expert #5, a more than 30-year veteran of the industry, has served in various positions in the private sector throughout his career including AREMA Committee 36 (on highway grade crossings warning systems). Prior to this study, Expert #5 had just completed investigation of two fatal accidents in the southern part of Chicago. Both accidents involved pedestrians and bicyclists who had not heeded existing warnings.

When Expert #5 was with the Illinois Central Railroad in the 1990s (before it was bought by the Canadian National) in charge of the signal department he would preach to his staff all the time that "... *it was our job, not necessarily to warn the aggressive driver. The aggressive driver has probably a heightened awareness of what's going on. But it's, what I used to refer to as the "soccer mom" following him. The unaware follower is the one who we are trying to do something to warn, the person who just plays follow-the-leader unaware – just thinking it's safe to do it because they did it. How do you educate them? How do you warn them?*"

Expert #5 cited information about safety cost allocation at grade crossings from Petit (2002) that can also be viewed in <http://www.billpetit.com/Papers/Petit009.pdf>. The following table (Table 4) is excerpted from the article and summarizes cost by each of the categories. Percentages shown reflect the average portion of the total cost that each category contributes. Percentages marked with a double asterisk (**) varied up to +/- 30% due to site-specific conditions.

Table 4. Cost Allocation

| Cost Category | Equipment / Services Included | Cost % (nonredundant detection) | Cost % (redundant detection) |
|--|--|---------------------------------|------------------------------|
| Housing Material | Bungalow, equipment rack assemblies, various adjustment resistors, and wires | 11.1% | 10.6% |
| Batteries and Chargers | Batteries and charging equipment | 3.0% | 2.8% |
| Ground Material | Foundations, ground rods, ducts, locks, cable, bondstrand and other external cabling | 4.1% | 3.9% |
| Warning Material | Gate mechanisms, brackets, counterweights, flashing lights, masts, and signs | 14.8% | 14.1% |
| Train Detection (non redundant) | Single set of uniform time warning equipment and track shunts | 6.7% | |
| Train Detection (redundant) | Fully redundant (with automatic switchover) uniform time warning equipment and track shunts | | 11.3% |
| Crossing Controller | Crossing control equipment, either relay or solid-state | 2.2% | 2.1% |
| Event Recorder | External event recorder including required inputs and outputs | 2.2% | 2.1% |
| Assorted Electrical/Electronic Equipment | Surge protection panels and equipment, battery chokes, etc. | 1.5% | 1.4% |
| Power Service | Equipment necessary to interface to commercial power systems and local utility charges for installing system | 4.6%** | 4.4%** |
| Engineering | Site surveys, logical crossing design, detailed wiring and equipment layout design, equipment assembly, wiring and factory testing | 13.0% | 12.3% |
| Freight | Cost of shipping the wired system to the physical field location | 3.3% | 3.2% |
| Installation | Cost of installing the equipment in the field, including final adjustments and field-testing | 33.4%** | 31.7%** |

Source: <http://www.billpetit.com/Papers/Petit009.pdf>.

Most of the major cost drivers are not dependent on equipment or technology. Installation, Engineering, Freight and Power Service alone are responsible for more than 50% of the crossing costs. One of the most frequently targeted areas for cost reduction is train detection, although it can be seen that only about 7% of the total crossing costs can be attributed to train detection (up to 12 % of a fully redundant system). The baseline cost also doesn't address some of the more difficult to quantify life-cycle costs. Note that these costs do not specifically address pedestrian crossings, but rather the engineering cost involved in a

system, the cost of obtaining power and backup power, and the cost of installation, and all in relative terms.

The information presented in Table 4 relates to the relative cost of sub-systems within a warning system. This is because the study didn't want to pin down what the absolute dollar value was given the considerable concern in the industry that a constant warning type system would only be only 10 or 15% of the total cost while the costs for a safety upgrade would be very different in urban and rural settings. For example, a \$250 to \$400 thousand project in an urban area triple-track crossing and a lot of highway traffic would be very different from a conventional installation of a set of flashing light signals at a single-track rural crossing for, say, \$40,000.

Expert #5 thinks that a simple set of flashing light signals at a crossing could still be installed for around \$80,000. The installation would include a conventional two signal setup, but no gates. In his opinion, it is still fairly economical to install a fail-safe system, and that's the important thing, to make it fail-safe.

The labor costs would be different, say, in an urban area or on Class 1 railroads because there are restrictions on working near the track when there is trains coming, so the greater the number of trains the less time is available to work near the track. Moreover, it is just more difficult to get around with more vehicular traffic and congestion.

Another factor affecting costs is the conflicting objective of installing warning devices in as many locations possible that can be reliable for the longest period of time possible. Some of the new technologically sophisticated systems may have a life expectancy of only five or ten years, while the legacy systems were expected to have a 30- to 40-year lifetime. The issue becomes more complicated by the fact that the railroad installs a warning system primarily with federal or state funding, but afterward the railroad is responsible for its maintenance for the long run. It is, therefore, in the interest of the railroad to install warning systems that are robust for a very long time. The above observations tend to end up driving up the costs per location, and so, over time, fewer locations are upgraded.

Such cost considerations also lower the emphasis on redundancy. All systems installed are fail-safe to begin with, but from a reliability standpoint, there is more emphasis on installing redundant systems, putting in monitoring systems that do alarm reporting. For example, if there is some malfunction at the crossing, the system might send in an alarm to a remote office, which improves reliability. With improved reliability the credibility of the system is also improved affecting thereby driver compliance. As Expert #5 remarked: "... *The thought is that you get better driver compliance by having more credible systems. If it's failsafe and it fails and it's always flashing, people ignore it. You want it to activate only when necessary, but when necessary you always want it to activate.*"

Expert #5 is a big advocate of video enforcement at crossings (in addition to low-cost, low-tech alternatives). This is probably more effective for motorists, but people generally tend to shy away if they know they are monitored, and thus pedestrians could end up being a little bit more conscious. However, the difficulty with the video enforcement is that the companies that do the video enforcement at intersections are not particularly interested to extend coverage to rail crossings because it doesn't fit into their business model. This is because most of their income is derived from violations and signal cycles at regular intersections are a lot more frequent compared to signal activations at rail crossings.

The video-enforcement companies basically provide the installation of the video equipment for free and then recoup their money based on some kind of monthly fee from the municipality. Thus, it doesn't fit into their business model of buying a set of video equipment to put it in conjunction with a pair of flashing light signals and gates on a project basis (vis-à-vis on a monthly fee type basis). It is one of those concepts that sounds good on paper but doesn't pan out as far as being able to implement.

Expert #6

Expert #6 has been with a Class I railroad for more than thirty years, the last ten in management. He told us that his organization has been routinely involved in safety upgrades at rail-highway grade crossings, and on rare occasions at exclusive pedestrian-rail grade crossings. The railroad's participation in the process usually starts from the early stages of the diagnostic review process especially in safety upgrades requiring signal preemption and power feed. During this process railroad staff becomes involved with municipal and state stakeholders, and, depending on the project scope, with the FRA safety experts. The need for safety upgrades is usually identified by the local stakeholders. Pedestrian-only safety upgrades usually receive lower priority mainly because of perceived lower cost-effectiveness. The diagnostic team sets the MUTCD standards for the safety upgrades. In addition, the FRA issues relevant safety guidelines that taken along with existing state MUTCD extensions complete the reference framework under which safety upgrades take place.

Expert #6's railroad is intensively involved in educational and outreach activities regarding trespassing usually through participation with Operation Lifesaver initiatives. Regarding enforcement, the railroad police are authorized to conduct civil arrests of trespassers that, unfortunately, more often than not are not prosecuted to the fullest extent of the law and are frequently thrown out by the judicial system. In an effort to educate the enforcement and judicial authorities, the railroad provides educational material for enforcement personnel and judges.

There is a persisting perception that trespassing is a railroad and thus a private problem. Expert #6 believes that trespassing should be adopted as a community problem. Such a cultural shift would offer a critical boost in mitigating the problem by leveraging local and railroad resources with other types of state and federal funding. In this regard, it would be most important that, in the new transportation bill reauthorization, the Section 130 funds continue to exclusively fund safety activities at rail crossings. The loss of such a dedicated funding source for rail crossings safety would have the additional negative impact of disrupting, perhaps critically, the development of relevant expertise at the FRA as well as at the state level.

Expert #7

Expert #7 has been with the United Transportation Union representing operating railroad employees since 1997, and has had a locomotive engineer experience with a Class I railroad prior to that. Drawing from his considerable experience in rail crossings safety, Expert #7 expressed his concern for the high variability of engineering costs among similar warning devices at different locations. He highly recommends state DOT participation and oversight in the allocation of such engineering costs. The process is already in place if it involves Section 130 funds.

Currently, the only level of participation in the state and federal government is authorizing the installation of a certain type of signal at a particular location, and then the railroads, are exercising the authority to install and integrate the signal within their own signal system. The large Class I railroads probably have dozens of similar crossing signal installations underway at any given point in time, and thus the additional engineering costs for similar systems should not be vastly different for different locations.

On the other hand, government oversight may be resisted by the railroads because, according to Expert #7, *"... if I can tell my draftsman, not my engineer, to go in and find the plans for River Road and change the milepost location to accommodate Frank Street, and in 10 minutes, I've got a \$55,000 engineering bill completed, I don't want to give that up."* The railroads argue that since they have the responsibility to install and maintain the equipment, it should be up to them to choose their own technology or specs – that can be also different from

the specs that are prescribed by the public authority – and so there may be the appearance of a conflict of interest. However, Expert #7 claims that the railroads today are free to install anything that they would like to install on their own property without cost considerations because they only pay a portion of the cost of the maintenance.

Expert #7 argues that the cost-effectiveness of pedestrian safety improvements at rail grade crossings would not be substantial enough to warrant the provision of additional funds at the state and federal level. To quote Expert #7, *“The problem today with pedestrians is identified as trespassers, and it’s illogical to make anyone in the appropriations process believe that if I am so distracted, that I would walk out in front of a train running as slow as 40 miles an hour blowing the whistle, that any additional warning devices – paint on the pavement or a gate in front of me or an additional red light flashing is going to bring me to awareness.”*

Trespassing, according to Expert #7, is a very serious problem, not only for the railroads that frequently run the risk of derailment when applying the emergency brakes, but also for the highway departments because the railroads, obviously, cannot fence in their right-of-way. The only deterrent that seems to work for trespassing is enforcement, which appears to be *“the weakest part of that chain.”* Predictably, lack of resources is one of the reasons. Another reason, especially, in smaller communities is that the local police would not normally go after a neighbor’s kids about walking on the railroad track. In addition to enforcement, community awareness and outreach can be very effective. In this regard, activities sponsored by the Operation Lifesaver are very helpful.

Expert #7 believes that there should be an emphasis to promote creative low-tech engineering improvements to increase situational awareness in certain environments. Additionally, if, say, a business relies on the sidewalks (at the crossing) to attract customers, it would be reasonable to expect that this business would voluntarily and willingly participate in a certain level of cost-sharing for safety improvements at that crossing. Another (non-engineering) option could be that a guard is assigned to help with vehicular and pedestrian traffic at a crossing during morning and evening rush hour.

Comments from Contacts in the U.S. DOT Modal Administrations

USDOT Official #1

Federal assistance to the nation’s rail-highway safety program is provided to the states via a formula-based distribution of title 23, United States code (USC), section 130 (hereafter referred to as ‘Section 130’) funds. The states are required to submit an annual report to the USDOT Secretary on the progress made to implement the program, the effectiveness of such improvements, an assessment of the costs of the various treatments employed, and subsequent collision experience at improved locations (<http://safety.fhwa.dot.gov/safetealu/guides/guide050506/>).

At a minimum, the report provides a discussion of: (a) location of projects; (b) USDOT crossing numbers; (c) FHWA roadway functional classification; (d) specific project type and description; (e) crossing protection (i.e., active, passive); (f) crossing type (e.g., vehicle, pedestrian, etc.); (g) cost of project; (f) funding types 9Section 130 or other); (g) crash data (a minimum of three years ‘before’ and three years ‘after’ crash data); and (h) effectiveness of prior projects (<http://safety.fhwa.dot.gov/safetealu/guides/guide050506/>).

Historically speaking, the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), which was signed into law on August 10, 2005, established the Highway Safety Improvement Program (HSIP) as a core Federal-aid program. The overall purpose of this program is to achieve a significant reduction in traffic fatalities and serious injuries on all public roads through the implementation of infrastructure-related highway safety improvements. As part of the HSIP, \$220 million is set aside each fiscal year for the

Railway-Highway Crossings Program (23 USC 130). These funds provide for the elimination of hazards and the installation of protective devices at public railway-highway crossings. More specifically, according to 23 USC(§ 148 : US Code - Section 148: Highway safety improvement program) these funds can be used (among other eligible expenses) for:

- Construction of any project for the elimination of hazards at a railway-highway crossing that is eligible for funding under Section 130, including the separation or protection of grades at railway-highway crossings.
- Construction of a railway-highway crossing safety feature, including installation of protective devices.
- The conduct of a model traffic enforcement activity at a railway-highway crossing.
- Installation and maintenance of signs (including fluorescent, yellow-green signs) at pedestrian-bicycle crossings and in school zones.

As a condition of obligating HSIP funds, a State is required to submit an annual report to the Secretary describing at least five percent of locations with the most severe safety needs, and an assessment of remedies, costs, and other impediments to solving the problems at each location. Reporting does not require an expense breakdown for pedestrian vis-à-vis highway improvements. A recent Volpe evaluation of the impact of the Section 130 program (among other factors) in the reduction of rail-highway crossing accidents revealed that the program is beneficial to crossing safety although a quantitative assessment would not be feasible to make due to lack of data at the federal level (Volpe, 2010).

USDOT Official #2

It would be very difficult to prioritize safety improvements at pedestrian rail grade crossings based on a formula, such as the APF used for rail-highway crossings. In the absence of such tools the preferred way is to use engineering judgment and experience and a diagnostic field review of the specific crossing in question. This is because each crossing is different, its requirements are different. The FRA is occasionally invited to participate in such local diagnostic teams.

The FRA is very often invited to appear and make presentations at national and international conferences on grade-crossing safety where they provide information and generalized guidance on an overview of a program. A recent example includes a recent workshop that brought together nationally and internationally recognized subject matter experts to collaborate, identify and prioritize specific research needs to facilitate the reduction of highway-rail grade crossing and trespass incidents and fatalities for incorporation into the strategic vision of FRA, other USDOT modes and their stakeholders (Carroll et al., 2010).

The FRA works very closely with Operation Lifesaver (OL) for trespassing prevention participating in meetings and field activities, and provides additional funding through annual grants to OL. This type of funding is required by regulations but its level varies from year to year. In addition, the FRA strongly supports risk-based hazard analysis which is used in the rail safety areas that they do have jurisdiction over. This task will be greatly facilitated by the changes in the way the FRA has started maintaining fatal trespass data from county based to lat/long based.

APPENDIX B SUPPLEMENTARY MATERIAL

MDOT DIAGNOSTIC REVIEW PROCESS

Michigan Department of Transportation's (MDOT) Diagnostic Study Team Review (DSTR) Process

The MDOT Freight Services and Safety Division holds DSTR's as a result of:

- The State's priority program [State determines what public highway-railroad at-grade crossings will be reviewed using the New Hampshire Index (see attached) and other crossing factors (i.e. current protection at crossings, crossing angle, etc.)]
- Road projects that may affect the crossing
- Safety concerns at a public crossing
- Public Crossings where a vehicle/train crash resulted in a fatality
- New public crossing requests

Per MCL 426.301 (The Railroad Code of 1993)

(1) The department, upon request of any interested party or by its own interest, may when it considers necessary assess the physical condition and safety needs of grade crossings of railroad tracks with public streets and highways or with a non-motorized trail by scheduling a diagnostic study team review at the grade crossing or group of grade crossings. Written notice shall be given to all parties 15 days before the review. Each affected organization shall be represented by a knowledgeable individual prepared to contribute information requested in the notice and empowered to make decisions on behalf of that party. A decision by a diagnostic study team concerning the safety needs of an at-grade crossing based upon current roadway and railroad traffic levels, speeds and other parameters, funding arrangements, division of responsibility, and scheduling will be mutually decided to accommodate adjustments or improvements, relocations, closures, grade separations, or other changes reasonably required in the interest of public welfare and safety. The department shall issue an order confirming the agreements reached, in writing, to all parties.

(2) If consensus cannot be reached during the diagnostic study team review, the department, by order, to the affected parties, shall require such adjustments or improvements, relocations, closures, or other changes as may be reasonably required in the interest of public welfare and safety. The railroad or railroads having responsibility for the track or tracks in the grade crossing, and the road authority having jurisdiction of the streets or highways shall be given due notice and have the right to a hearing.

Typically, a railroad, road authority, or trail authority requests a DSTR, MDOT schedules the DSTR and an MDOT Railroad Safety Inspector facilitates it. The railroad and road authority/trail authority must be present. Other stakeholders are also invited (utility companies, law enforcement, adjacent business owners, etc.).

During the DSTR, the Safety Inspector gathers numerous pieces of data pertaining to the crossing and includes them in the report (see attached DSTR Report).

All parties have 15 days to review the DSTR report and provide feedback. An official Confirming Order (for existing crossings) or Authorizing Order (for new crossings) is issued after the 15-day review period has expired (see attached Order).

We have an Order Compliance Tracking System used to track the status of the ordered work.

Please review our website at www.Michigan.gov/MDOTRailFreight to obtain a copy of the Diagnostic Study Team Review Request form, The Michigan Guidelines for Traffic Control Devices at Highway-Railroad Grade Crossings, and the MMUTCD. You will also find a copy of Michigan Railroad Statutes under the "Regulatory" section of the website.

I have attached a list of the pedestrian/trail crossings that we have in our database. Please note this does not include sidewalk crossings or trail crossings that are included in an at-grade roadway crossing.

Our Operation Lifesaver Director is Sam Crowl, he can be reached at (248) 823-7037, or at samcrowl@comcast.net.

DESIGN, INSTALLATION, COMPONENT, MAINTENANCE AND OPERATING COSTS

The average cost of a highway-railroad grade crossing safety enhancement project is roughly \$150K - \$175K. A typical breakdown of costs for a crossing warning system such as flashing light signals and half-roadway gates includes approximately \$10K in design and engineering work, \$15K-\$35K in equipment charges, \$60-\$80K in warning device components, and \$60K-\$80K in labor and installation costs. These costs vary depending on the type of railroad involved and the crossing environment, as prices can differ widely between Class 1 railroads and short lines, while multiple tracks, roadway lanes or adjacent signal devices may also require additional effort and expense.

After installation, active warning devices are maintained in accordance with federal regulations that require monthly, quarterly, and annual inspections and system testing. Average annual maintenance expenses can range from \$2500 to \$5000 depending on the complexity of the system.

Operating costs are comparable to highway traffic signal operations, with annual power costs in the range of \$300 - \$600, again depending on the complexity of the system.

System design and installation costs are compiled from federal and state-funded safety enhancement projects. The above-referenced maintenance and operating costs are derived from reports submitted by railroads in relation to their ongoing expenses for active warning device systems at public highway crossings.

TEMPLATE REPORT OF A TXDOT DIAGNOSTIC STUDY

(Source: Darin Kosmak)

**FINAL INSPECTION REPORT
FOR RAILROAD SIGNAL PROJECTS**

**CREATE BLANK PAGES AT THE BOTTOM OF THIS DOCUMENT FOR INCLUSION OF DIGITAL
PHOTOS AND SEND PHOTOS IN ELECTRONIC FORMAT TO RAIL DIVISION**

Location:
Street/Highway:
County:
Project No.:
CSJ:

Railroad:
DOT No.:
Milepost:
Date of Inspection:
Placed in Service Date:

Based on our final inspection the following items are noted as per the approved plans, and in accordance with the Texas Manual on Uniform Traffic Control Devices (TMUTCD).

WORK DONE BY THE ROAD AUTHORITY/CONTRACTOR:

STOP LINES AND RxR MARKINGS

Shown on Plans yes no (If yes please check below, if no explain)
Installed Correct
Needs Repainting
Installed Incorrect

Remarks: _____

CENTERLINE, LANE LINES, EDGE LINES

Shown on Plans yes no (If yes please check below, if no explain)
Installed Correct
Needs Repainting
Installed Incorrect

Remarks: _____

ADVANCE WARNING SIGNS (W10-XX)

Installed According to the Plans yes no (If no please comment below)

Remarks: _____

REGULATORY SIGNS (R15-1, R15-2, R15-4, R8-8)

Installed According to the Plans yes no (If no please comment below)
DOT Number Correct yes no (if no please comment below)
Phone Number Correct yes no (if no please comment below)
(1-800-772-7677)

Remarks: _____

CURB AND GUTTER, MEDIANS, SIDEWALK

Installed/Adjusted According to Plans yes no (If no please comment below)

Remarks: _____

DRAINAGE PIPE, CULVERT EXTENSIONS, RETAINING WALL

Installed According to the Plans yes no (If no please comment below)

Remarks: _____

APPROACH REALIGNMENT, APPROACH GRADE ADJUSTMENT

Constructed According to Plans yes no (if no please comment below)

Remarks: _____

METAL BEAM GUARD FENCE

Installed According to the Plans yes no (If no please comment below)

Remarks: _____

INTERIM SIGNS REMOVED (YIELD/YIELD AHEAD, STOP/STOP AHEAD, NO LIGHTS)

Removed yes no (If no please comment below)

Remarks: _____

VEGETATION CONTROL

Adequate Visual Clearance yes no (If no please comment below)

Remarks: _____

CROSSING SURFACE

Installed according to plans yes no (if no please comment below)

Remarks: _____

UTILITIES

Adjusted according to plans yes no (if no please comment below)

Remarks: _____

WORK DONE BY THE RAILROAD/CONTRACTOR:

WARNING DEVICES (LIGHT ASSEMBLIES)

Installed According to the Plans yes no (If no please comment below)

Remarks: _____

Front Lights Aimed Correctly yes no (If no please check below)
Lights Readjusted at Time of Inspection yes no (if no please comment below)

Remarks: _____

Back Lights Aimed Correctly yes no (if no please check below)
Lights Readjusted at Time of Inspection yes no (if no please comment below)

Remarks: _____

Side Lights Aimed Correctly yes no (if no please check below)
Lights Readjusted at Time of Inspection yes no (if no please comment below)

Remarks: _____

WARNING DEVICES (GATE ASSEMBLIES)

Installed According to the Plans yes no (If no please comment below)

Remarks: _____

DOT NUMBER STENCILED ON EACH SIGNAL MAST

Installed According to the Plans yes no (If no please comment below)

Remarks: _____

INSTRUMENT HOUSE

Installed According to the Plans yes no (If no please comment below)

Remarks: _____

TYPE OF CIRCUIT

Phase Motion (PMD)
Constant Warning (CWT)

Other type: _____

Remarks: _____

APPENDIX C SURVEY INSTRUMENT

SRL CASEID # _____
 DATE _____
 INTERVIEWER # _____

Survey of Pedestrian Safety at IL RR Crossings

1. First we'd like to know how often you use this pedestrian crossing. Please tell us either how many times per DAY you use this crossing, or how many times per WEEK you use it, or how many times per MONTH you use it, or how many times per YEAR you use it. (ENTER ONE NUMBER ONLY)
 - _____per day
 - _____per week
 - _____per month
 - _____per year
 - First Time/irregularly

2. Did you notice or did you not notice any signs or warning devices at this pedestrian crossing?
 - Did notice → 2a. What signs and warning devices did you notice at this pedestrian crossing? (DO NOT READ LIST. CHECK ALL THAT APPLY)
 - Did not notice
 - Detectable, audible or visual warnings for people with disabilities
 - Fencing, swing gates, or zigzag
 - Flashing lights
 - Pedestrian crossing gate(s)
 - Pavement markings/Pavement change
 - Ringing bells
 - Second-train-coming electronic warning signs
 - Signs → SPECIFY: _____
 - Other → SPECIFY: _____

3. Would you cross these tracks when the lights are flashing, the bells are ringing, or the gates are down if...

| | Yes | No |
|--|--------------------------|--------------------------|
| a. You felt that there was enough time to get across safely? | <input type="checkbox"/> | <input type="checkbox"/> |
| b. Other people were crossing? | <input type="checkbox"/> | <input type="checkbox"/> |
| c. You were in a hurry? | <input type="checkbox"/> | <input type="checkbox"/> |
| d. You were annoyed at having to wait for the train to pass? | <input type="checkbox"/> | <input type="checkbox"/> |
| e. You could not see a train coming? | <input type="checkbox"/> | <input type="checkbox"/> |

4. How often have you seen other pedestrians crossing these tracks when the lights are flashing, the bells are ringing, or the gates are down...
 - Never?
 - Occasionally?
 - Sometimes?
 - Often?
 - Always?

5. Some pedestrians cross at locations other than the official pedestrian crossing, how often have you crossed these tracks at a location other than the official pedestrian crossing?
 - Never? → GO TO Q8
 - Occasionally?
 - Sometimes?
 - Often?
 - Always?

Crossing Location: _____

Circle all that apply: Biking Walking Skateboard
 Rollerblading Wheelchair Walking aid Pushing cart
 Pushing stroller With young children
 Music on earphone On cell phone Texting

Time: _____

Gender: Male Female

Direction of Travel:
 Circle one: North East South West

Survey of Pedestrian Safety at IL RR Crossings

6. Where else do you cross these tracks? Do you cross...
- | | Yes | No |
|---------------------------------|--------------------------|--------------------------|
| a. Through the emergency gates? | <input type="checkbox"/> | <input type="checkbox"/> |
| b. Through the road crossing? | <input type="checkbox"/> | <input type="checkbox"/> |
- c. A location other than the official pedestrian crossing? → SPECIFY: _____
7. What are some reasons why you might cross these tracks at a location other than the official pedestrian crossing? (DO NOT READ LIST. CHECK ALL THAT APPLY)
- | | |
|---|--|
| <input type="checkbox"/> I felt I had enough time to get across safely. | <input type="checkbox"/> The train was stopped. |
| <input type="checkbox"/> Other people were crossing. | <input type="checkbox"/> I could not see a train coming. |
| <input type="checkbox"/> I previously crossed when a train was coming and was not hurt. | <input type="checkbox"/> I was in a hurry. |
| <input type="checkbox"/> Other (please specify) _____ | |
8. Do you think it is legal or do you think it is illegal for pedestrians to cross the tracks when the lights are flashing, the bells are ringing, or the gates are down, even if the train is not there yet?
- Legal
 Illegal
9. How safe do you feel using this pedestrian crossing? Do you feel...
- Extremely safe?
 Very safe?
 Moderately safe?
 Slightly safe?
 Not at all safe?
10. How difficult is it to cross these tracks? Do you think it is...
- Extremely difficult?
 Very difficult?
 Moderately difficult?
 Slightly difficult?
 Not at all difficult? → GO TO Q12
11. What makes crossing these tracks difficult? (CHECK ALL THAT APPLY)
- Visual pollution/can't see signs
 Signs are not reflective at night
 Audible devices are not loud enough
 The direction of the path/sidewalk is not clear
 The surface of the path/sidewalk is in disrepair, e.g. cracked or broken
 The line of sight to view an approaching train is obstructed by trees, a lamp post, etc.
 The second train warning sign has a glare/ is difficult to read
 Other → SPECIFY: _____
12. What else could be added to improve safety at this pedestrian crossing? (DO NOT READ LIST. CHECK ALL THAT APPLY)
- Detectable, audible or visual warnings for people with disabilities
 Fencing, swing gates, or zigzag
 Flashing lights
 Pedestrian crossing gate(s)
 Pavement markings/Pavement change
 Ringing bells
 Second-train-coming electronic warning signs
 Signs → SPECIFY: _____
 Other → SPECIFY: _____
 Nothing/no improvements needed
13. (RECORD AND SPECIFY IF OBVIOUS IMPAIRMENT OR IF R HAS ALREADY STATED IMPAIRMENT AND ASK THE FOLLOWING QUESTION) Do you have any physical, visual, auditory, or any other kind of disability?
- Yes → SPECIFY: _____
 No
14. In what year were you born? _____
15. And can I get the highest grade or level of education you have completed?
- 8th grade or less
 Some high school
 High School graduate/GED
 Some College
 College or other advanced degree

APPENDIX D ANSWERS TO COMMON RESPONDENT QUESTIONS

~ **What is this study about?**

We are looking at the behavior of pedestrians and bicyclists, who use various rail crossings around Northeastern Illinois, to understand their experiences at these crossings.

~ **Who is doing this study?**

Researchers from the University of Illinois at Chicago's Urban Transportation Center and Survey Research Laboratory are conducting these surveys.

~ **Who is paying for the research?**

The research is being funded by the Illinois Department of Transportation (IDOT).

~ **How was I selected for the survey?**

We are asking pedestrians and bicyclists who cross these tracks at specific times during the day.

~ **What will happen to my answers / Will my answers be kept confidential?**

Your answers will be kept completely confidential and will be looked at in summary form only.

~ **How long will this take?**

It takes two minutes to complete the questionnaire on average. If you would like, I can walk with you as I ask you questions.

~ **What are the questions like on the questionnaire?**

The questions ask about the crossing and your experiences at the crossing.

~ **Who can I call to verify the survey or get more information?**

You may call Jessica Hyink, who is the project coordinator at the University of Illinois Survey Research Laboratory. Her number is (312) 996-5029 and she can be reached during business hours. If you like, you may call collect.

~ **Why should I participate?**

Your experiences are important to us and we want to hear what you have to say. Your responses may be used to help benefit the future of pedestrian and bicycle safety at rail crossings.

~ **How do I apply for a job at SRL?**

You can visit the website at www.srl.uic.edu and apply for a job online. If we have positions available, we will contact qualified individuals to come in for interviews.

APPENDIX E ORAL INFORMED CONSENT SCRIPT

Hello, my name is _____ and I am with the Survey Research Laboratory at the University of Illinois at Chicago. We are conducting a survey about the experiences of pedestrians and bicyclists with active and passive warning signs at highway-rail and pathway-rail grade crossings around Northeastern Illinois. Your responses may be used to help benefit the future of pedestrian and bicycle safety at rail crossings in this country. Would you be interested in completing a quick survey? It should only take a few minutes.

Have you participated before?

Yes. → I'm sorry; we can only interview people once. Thank you for participating last time!

No.

Are you over 18 years of age?

Yes. → Thank you! I'll move through the questions as quickly as possible.

No. → I'm sorry, we can only interview people over the age of 18. Thank you for your interest!

APPENDIX F INFORMATION SHEET

Project Title: Pedestrian / Bicyclist Warning Devices & Signs at Highway-Rail & Pathway-Rail Grade Crossings

Purpose of the Study: We are looking at the behavior of pedestrians, who use various rail crossings around Northeastern Illinois, to understand their experiences at these crossings. The proposed research will evaluate the adequacy and effectiveness of existing signs, markings, and/or flashing lights in use at highway-rail and pathway-rail grade crossings. This research includes designated walkways/bikeways such as city sidewalks, non-designated walkways/bikeways such as roadway shoulders, and passenger/transit station crossings.

We are asking for your participation to understand your experiences with active and passive warning signs at the crossing you are visiting today. The survey should take approximately 2–5 minutes of your time.

Your participation in this study is entirely voluntary, and you can skip any questions you do not want to answer. All the information you provide will be kept completely confidential and will be presented in summary form only.

Although your participation in the research will not directly benefit from you, the research may be of benefit to the future of pedestrian and bicycle safety at rail crossings in this country.

If you have any questions about this study, feel free to ask them now or contact: Jessica

Hyink, Project Coordinator
Survey Research Laboratory
College of Urban Planning and Public Affairs
University of Illinois at Chicago
Phone: (312) 996-5029 e-mail: jhyink2@uic.edu

OR

Dr. Paul Metaxatos, Research Assistant Professor
Urban Transportation Center
College of Urban Planning and Public Affairs
University of Illinois at Chicago
Phone: (312) 996-4713 e-mail: pavlos@uic.edu

If you have any questions about your rights as a research subject, you may write or call OPRS at the following address:

Office for the Protection of Research Subjects (OPRS)
1737, W. Polk Street, M/C 672
203 Administrative Office Building
Chicago, Illinois – 60612.
Phone: (312) 996 1711 or toll free: 866-789-6215
Email uicirb@uic.edu

APPENDIX G VIDEO EQUIPMENT AND SPECIFICATIONS



Figure 1. Video camera and tripod - (http://greenway-consulting.com/images/ScoutVCU_Spec_Sheet.pdf - Accessed 9/14/2011.)

Technical Specifications of the Video Monitoring Equipment

Control Box

- Record Length: 72 hrs internal battery (7 days with Power Pack)
- Battery Recharge Time: ~5 hrs
- Memory Card Included: 16 GB SD card (can store up to 90 hrs of video)
- Memory Capacity: 2 slots x 32 GB = 64 GB (can store up to 360 hrs of video)
- Screen: 5.6 in (~14 cm) LCD
- Camera: Low-light (0.03 lux), Wide-angle lens
- GPS: Mapping, time
- USB: 3 ports
- Weather: All weather conditions
- Temperature Range: -40°F to 176°F (-40°C to 80°C)

Pole-mount

- Deployed Height ~25 ft (~7.6 m)
- Collapsed Height: ~4.3 ft (~1.3 m)
- Width: 14 in (~35.6 cm)
- Weight: 17.4 lbs (~7.9 kg)
- Depth: 11 in (~28 cm)
- Maximum Wind Load: 50 mph (~80.5 km/h)

Tripod

- Weight: 17 lbs (7.71 kg)
- Footprint: ~5 ft (1.5 m)
- Collapsed Height: ~4 ft (1.2 m)
- Security Weights: 3 x 40 lbs (18.1 kg) = 120 lbs (54.4 kg)
- Maximum Wind Load: 50 mph (~80.5 km/h)

References

http://greenway-consulting.com/images/ScoutVCU_Spec_Sheet.pdf - Accessed 9/14/2011.

APPENDIX H VIDEO RECORDING LOCATIONS



Figure 1. Camera location at the crossing on 119th Street in Chicago.



Figure 2. Crossing 608830M – A view from the ground.

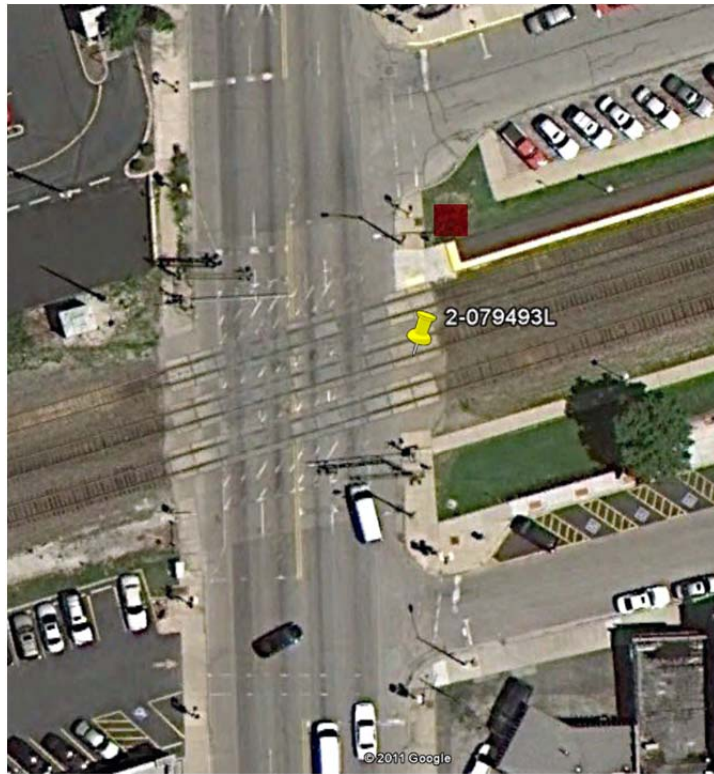


Figure 3. Camera location at the crossing on Harlem Avenue in Riverside.



Figure 4. Crossing 079493L – A view from the ground.



Figure 5. Camera location at the crossing on Nagle Avenue in Chicago.



Figure 6. Crossing 173887G – A view from the ground.



Figure 7. Camera location at the crossing on LaGrange Road in LaGrange.



Figure 8. Crossing 079508Y – A view from the ground.

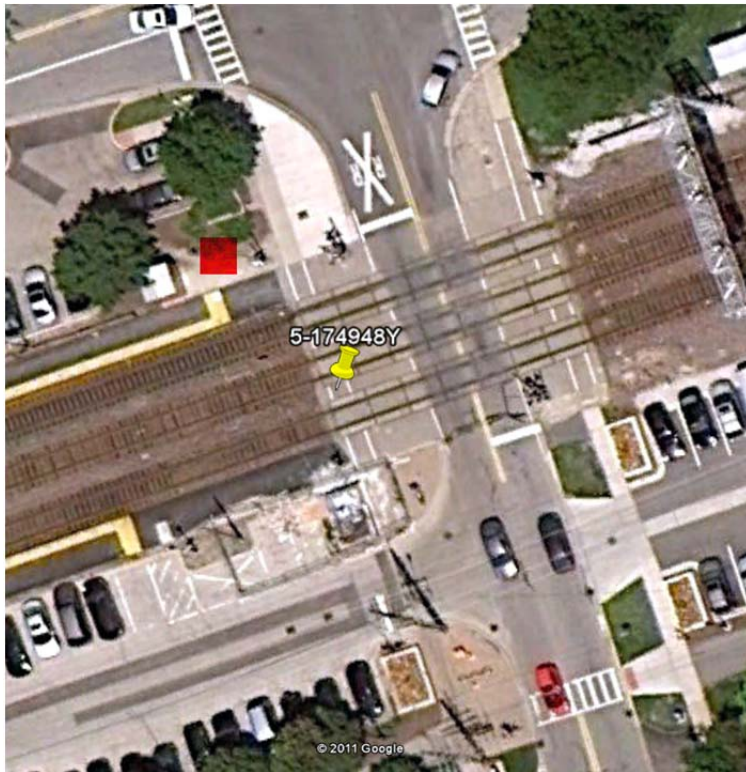


Figure 9. Camera location at the crossing on Park Boulevard in Glen Ellyn.



Figure 10. Crossing 174948Y – A view from the ground.



Figure 11. Camera location at the crossing on Marquette Road in Chicago.



Figure 12. Crossing 843811C – A view from the ground (courtesy of ICC).



Figure 13. Camera location at the crossing on Osterman Avenue in Deerfield.



Figure 14. Crossing 388040W – A view from the ground.

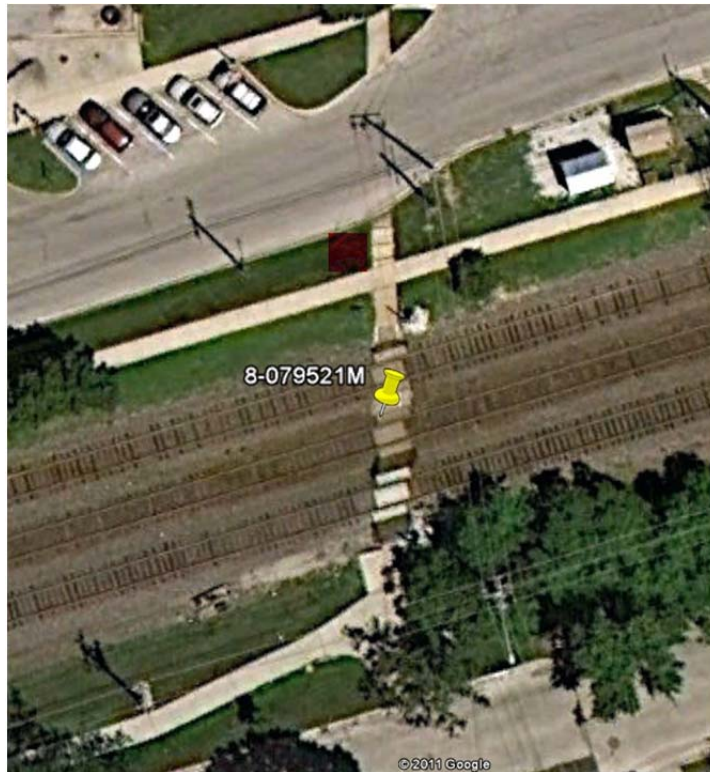


Figure 15. Camera location at the crossing on Park Street in Hinsdale.



Figure 16. Crossing 079521M – A view from the ground.

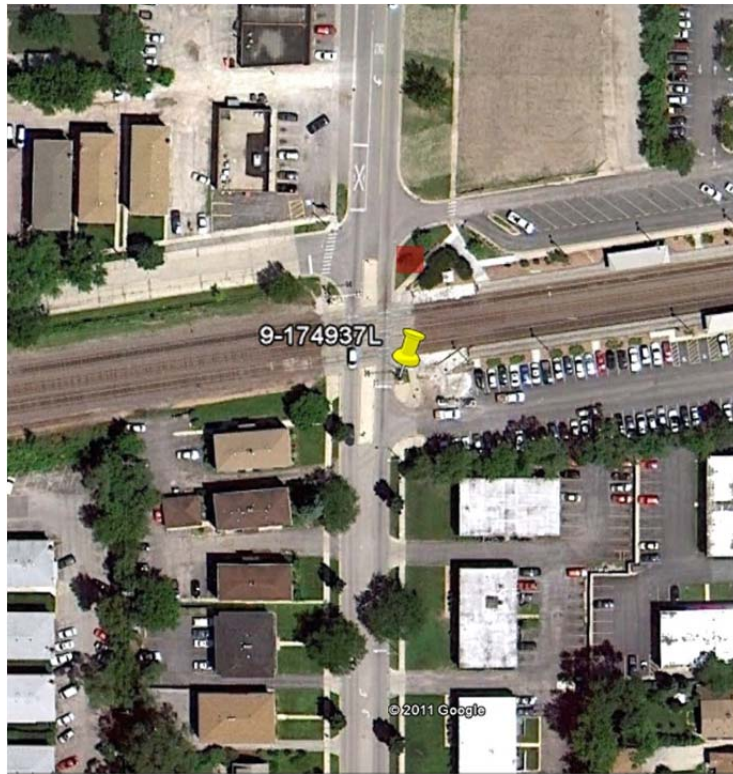


Figure 17. Camera location at the Villa Park Depot crossing in Villa Park.



Figure 18. Crossing 174937L – A view from the ground.



Figure 19. Camera location at the Elmwood Park Depot crossing in Elmwood Park.



Figure 20. Crossing 372128W – A view from the ground.

APPENDIX I DATABASE CHARACTERISTICS

Database Attributes from Video Observations

| Field | Explanation | Format | Possible Values |
|--------------------------------------|---|-----------|--------------------|
| Video File Name | MP4 file name | Text | NA |
| Entered by | Initials of data entry clerk | Text | NA |
| Video Start time | | time (24) | NA |
| Crossing Number | Crossing ID | Text | NA |
| Date | Date video taken | Date | NA |
| Crossing name | | Text | NA |
| Crossing distance | rail to rail distance | Number | NA |
| Part of platoon | Solo crosser or platoon | Text | Yes, No |
| # in Platoon | | Number | Integers |
| Direction | Direction (N, S, E, W) from which the pedestrian approached the crossing | text | N,S,E,W |
| Side of street | | text | N,S,E,W |
| Pedestrian path | | text | Straight, Diagonal |
| Pedestrian enter crossing time (min) | # of minutes elapsed since start of video to pedestrian entering crossing | number | Integers |
| Pedestrian enter crossing time (sec) | | number | Integers |
| Pedestrian exit crossing time (min) | # of minutes elapsed since start of video to pedestrian exiting crossing | number | Integers |
| Pedestrian exit crossing time (sec) | | number | Integers |
| Gate Activity | Whether the pedestrian was at the crossing during a gate activation | text | Yes, No |
| Violation type | 1: (Lights flashing only); 2: (Gate in motion), 3: (Gate in down position) | text | 1, 2, 3 |
| Train Coming or Gone | For peds with gate activity, whether they entered the crossing when a train was coming towards the crossing or all trains had already gone through) | text | C, G |
| Crossing activation time (min) | # of minutes elapsed since start of video to flashing lights activating | number | Integers |
| Crossing activation time (sec) | | number | Integers |
| Crossing de-activation time (min) | # of minutes elapsed since start of video to flashing lights deactivating | number | Integers |
| Crossing de-activation time (sec) | | number | Integers |
| Comments | | text | NA |

| | | | |
|--|---|-----------|---------------------------------------|
| PedEnterCross | Time (24 hour format) when pedestrian entered crossing | time (24) | NA |
| PedExitCross | Time (24 hour format) when ped exited crossing | time (24) | NA |
| Interval_15 | Start time of assigned 15-minute time interval | time (24) | NA |
| Timetocross | Duration of rail-to-rail crossing time for pedestrians | time (24) | NA |
| CrossAct | Time (24 hour format) when flashing lights activated | time (24) | NA |
| CrossDeact | Time (24 hour format) when flashing lights deactivated | time (24) | NA |
| TimeActive | Duration of gate activation | time (24) | NA |
| Pedestrians present at crossing? | If pedestrians were present in the gate or crossing area during gate activation | text | Y,N |
| Violations (#) | Number of pedestrian violations | number | integers |
| Train presence | Whether or not a train entered the crossing during a gate activation (if not: false alarm/gate malfunction) | text | Yes, No |
| Train arrival time (min) | # of minutes elapsed since start of video to train entering crossing | number | integers |
| Train arrival time (sec) | | number | integers |
| Train departure time (min) | # of minutes elapsed since start of video to train exiting crossing | number | integers |
| Train departure time (sec) | | number | integers |
| Type of train | | text | Freight, Passenger, Track Maintenance |
| Direction from which the train approached the crossing | | text | N, S, E, W |
| Second train event | Whether a second (or third) train was present during the gate activation | text | Yes, No, NA |
| TrainArrive | Time (24 hour format) when train entered crossing | time (24) | NA |
| TrainDepart | Time (24 hour format) when train exited crossing | time (24) | NA |
| TrainInCrossing | Time elapsed while train was present in crossing | time (24) | NA |

APPENDIX J 15-MINUTE PEDESTRIAN COUNTS AT STUDY CROSSINGS

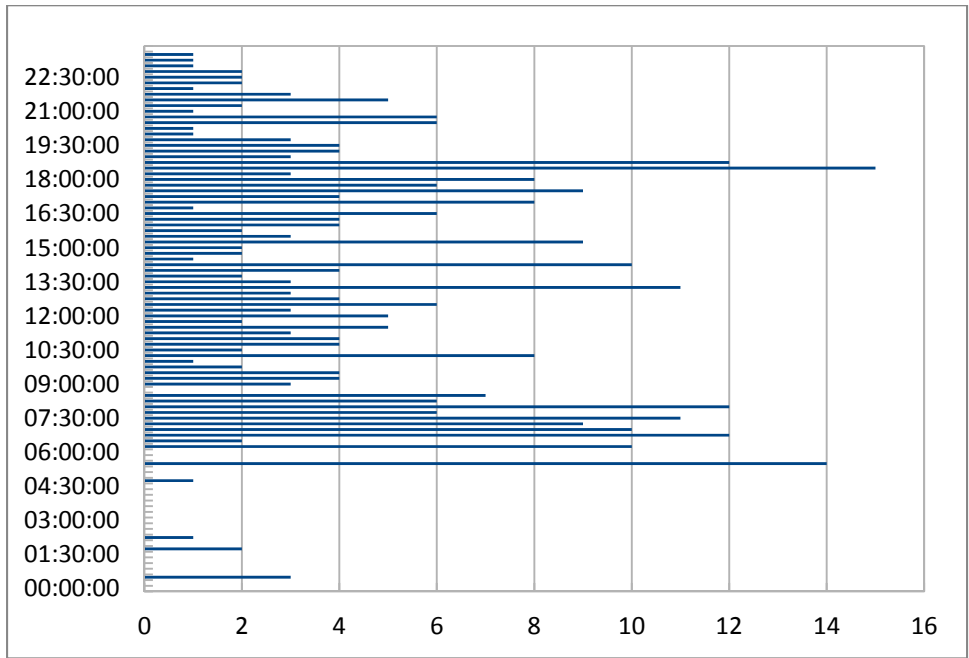


Figure 1. 15-minute pedestrian counts at 119th Street crossing.

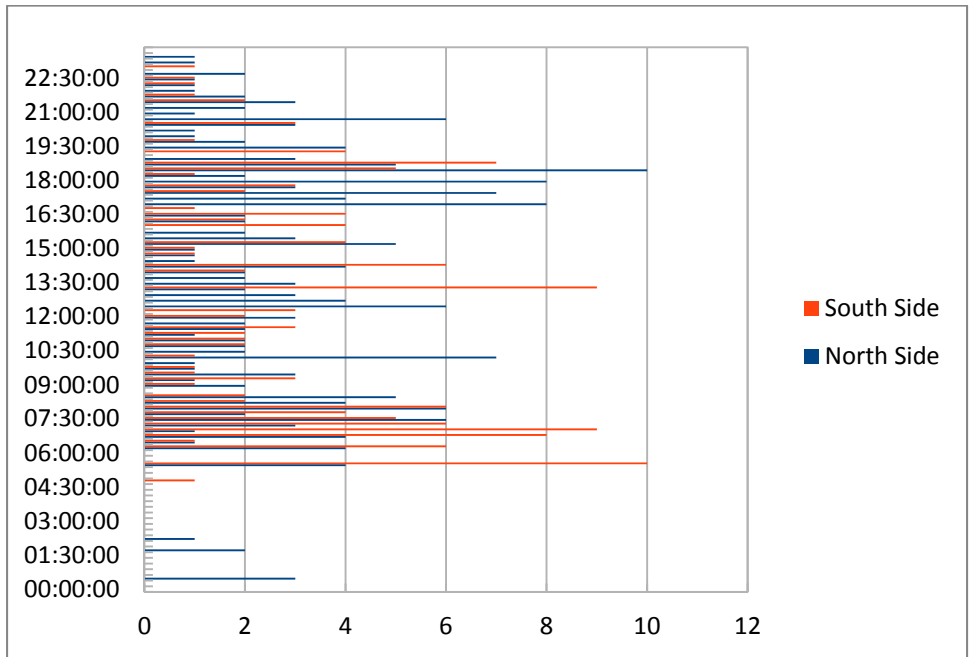


Figure 2. 15-minute pedestrian sidewalk counts at 119th Street crossing.

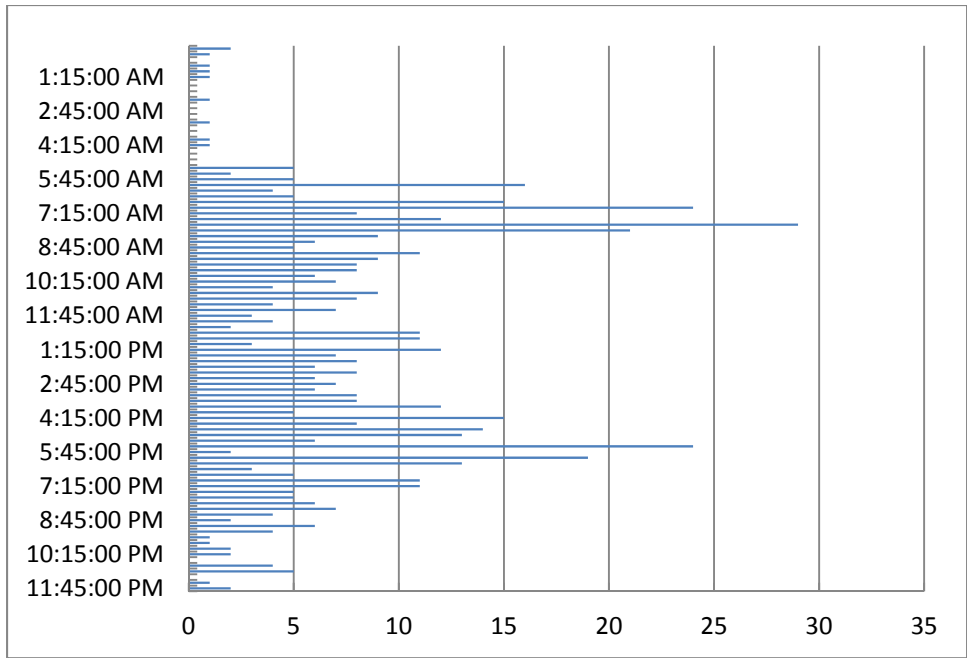


Figure 3. 15-minute pedestrian counts at Harlem Ave. crossing.

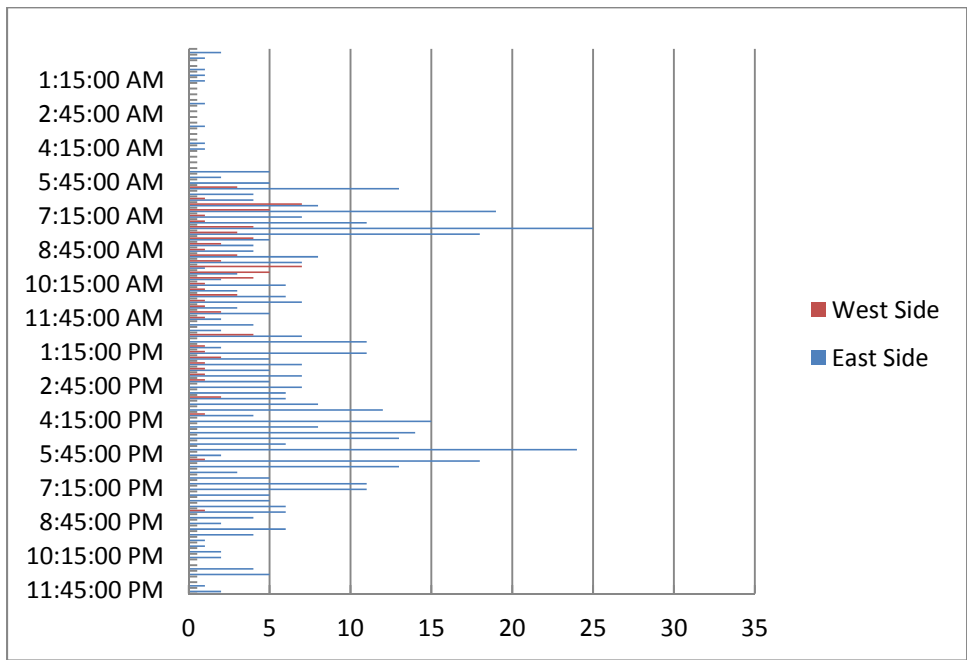


Figure 4. 15-minute pedestrian sidewalk counts at Harlem Ave. crossing.

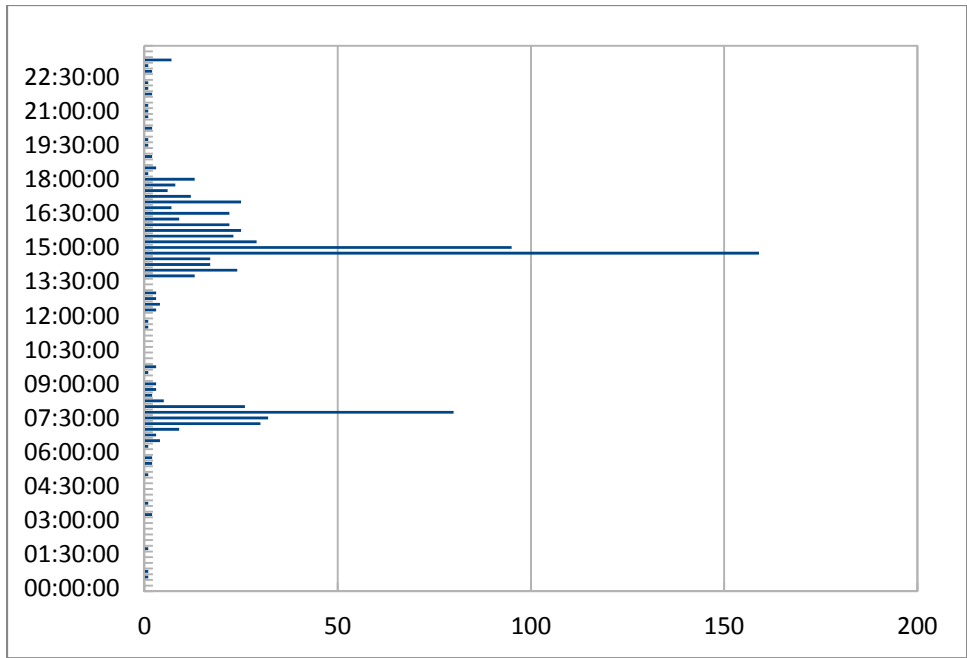


Figure 5. 15-minute pedestrian counts at Nagle Ave. crossing.

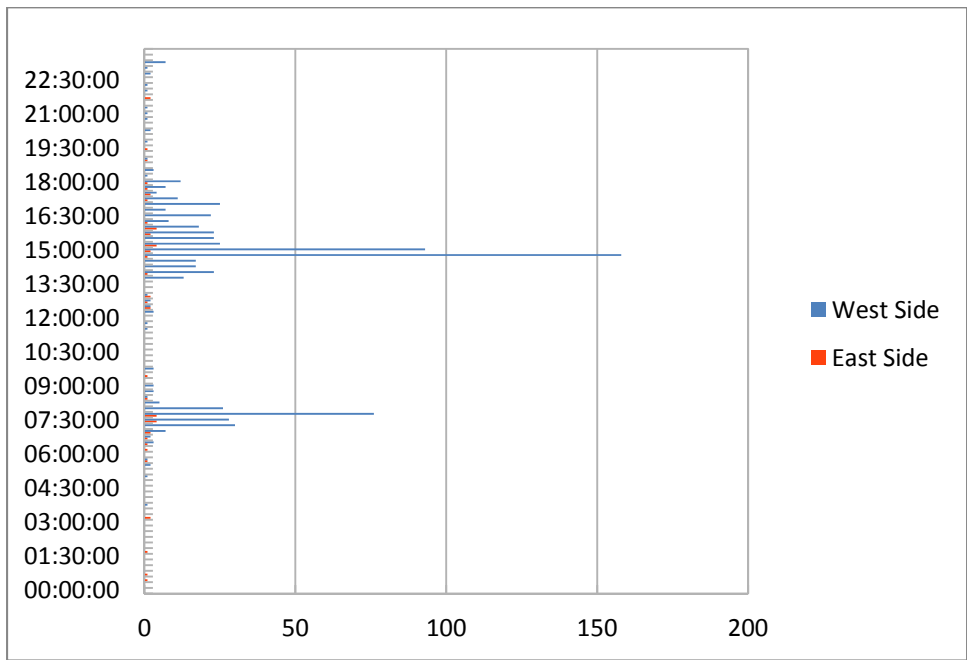


Figure 6. 15-minute pedestrian sidewalk counts at Nagle Ave. crossing.

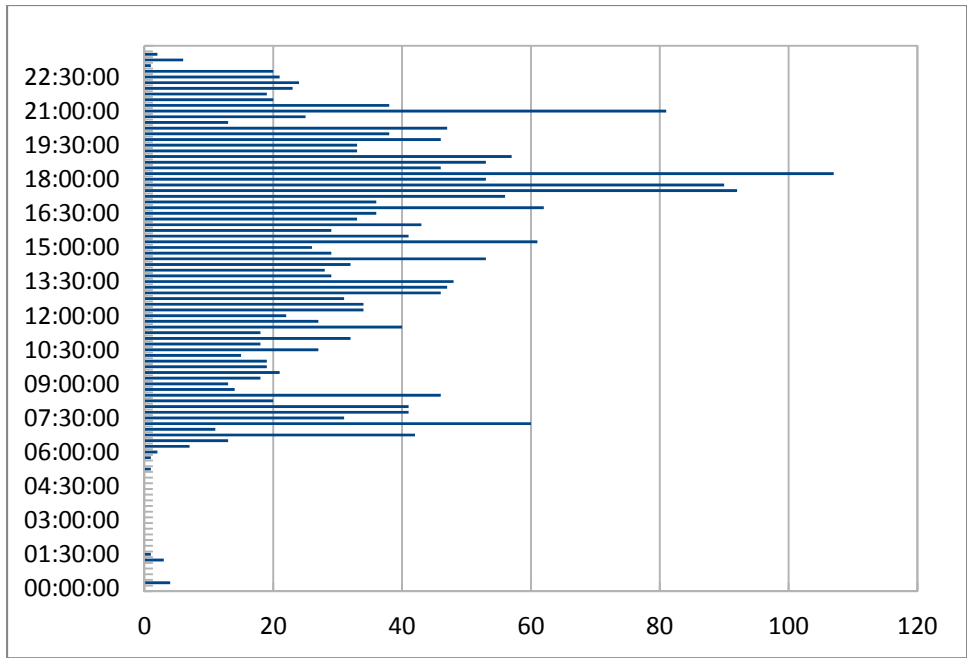


Figure 7. 15-minute pedestrian counts at LaGrange Rd. crossing.

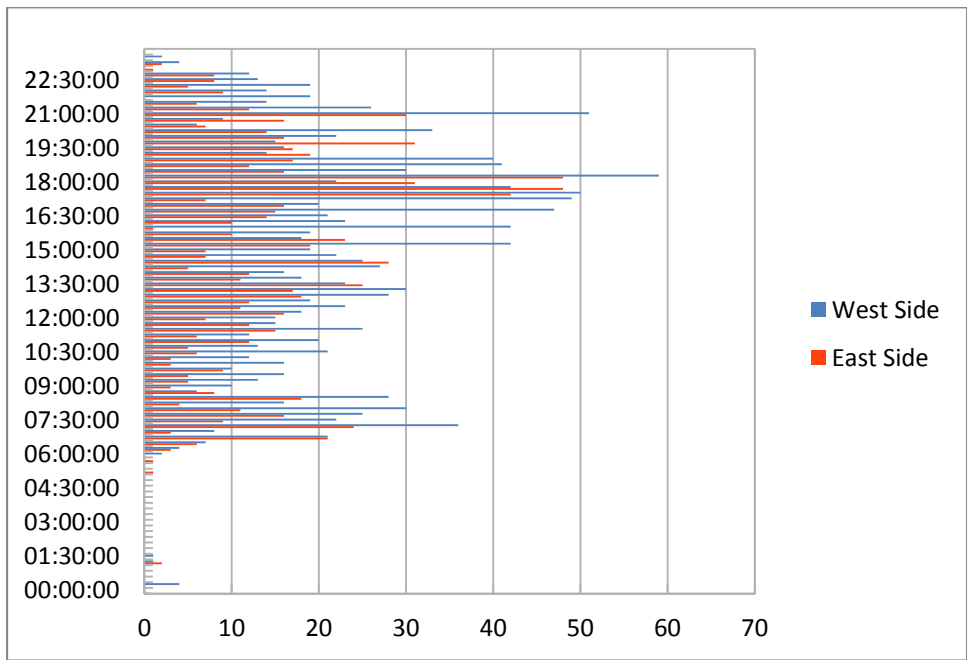


Figure 8. 15-minute pedestrian sidewalk counts at LaGrange Rd. crossing.

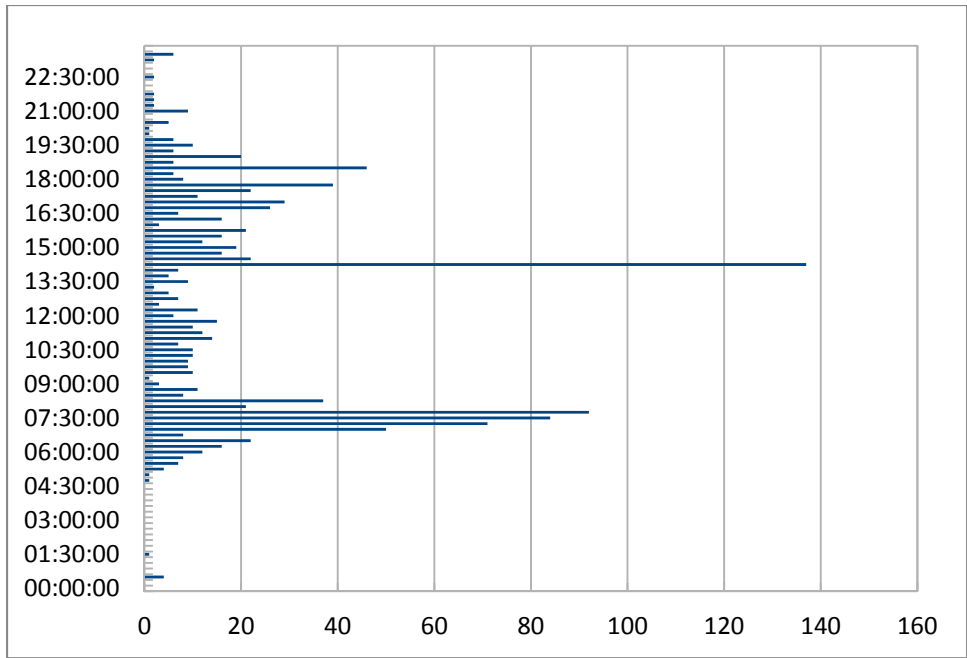


Figure 9. 15-minute pedestrian counts at Park Blvd. crossing.

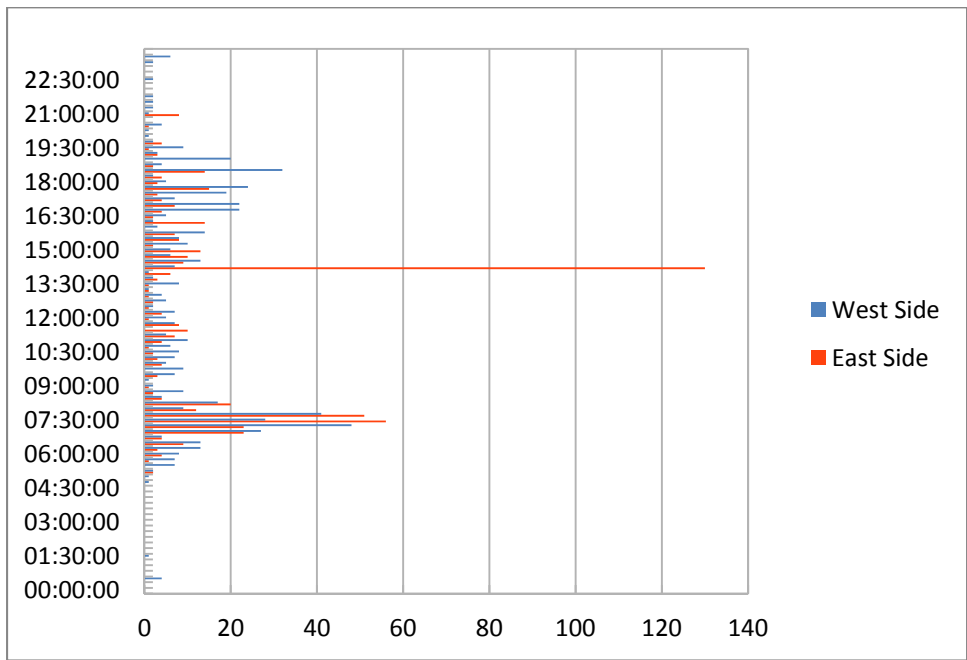


Figure 10. 15-minute pedestrian sidewalk counts at Park Blvd. crossing.

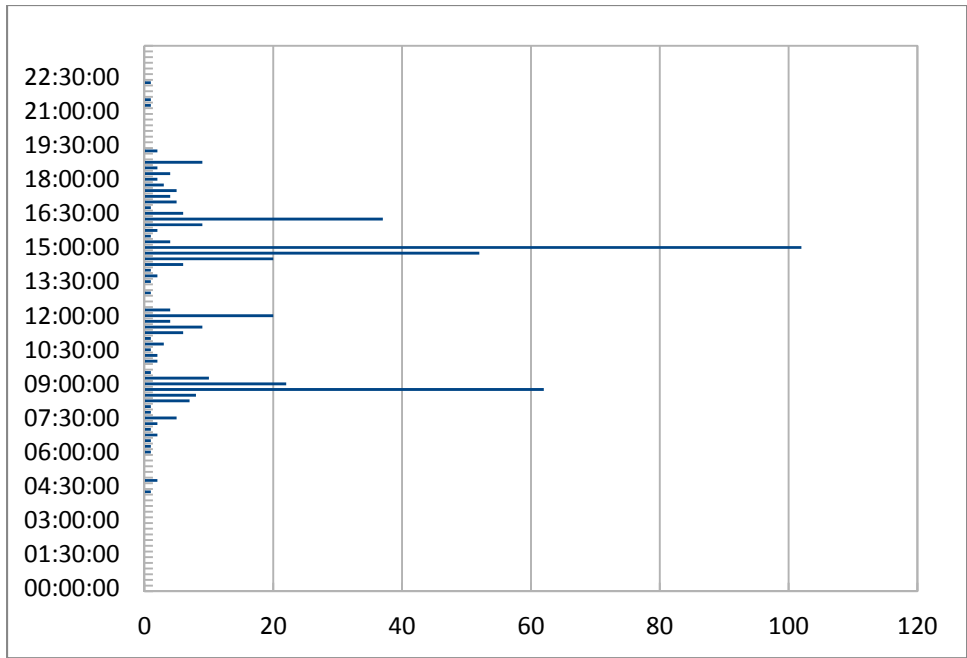


Figure 11. 15-minute pedestrian counts at Marquette Rd. crossing.

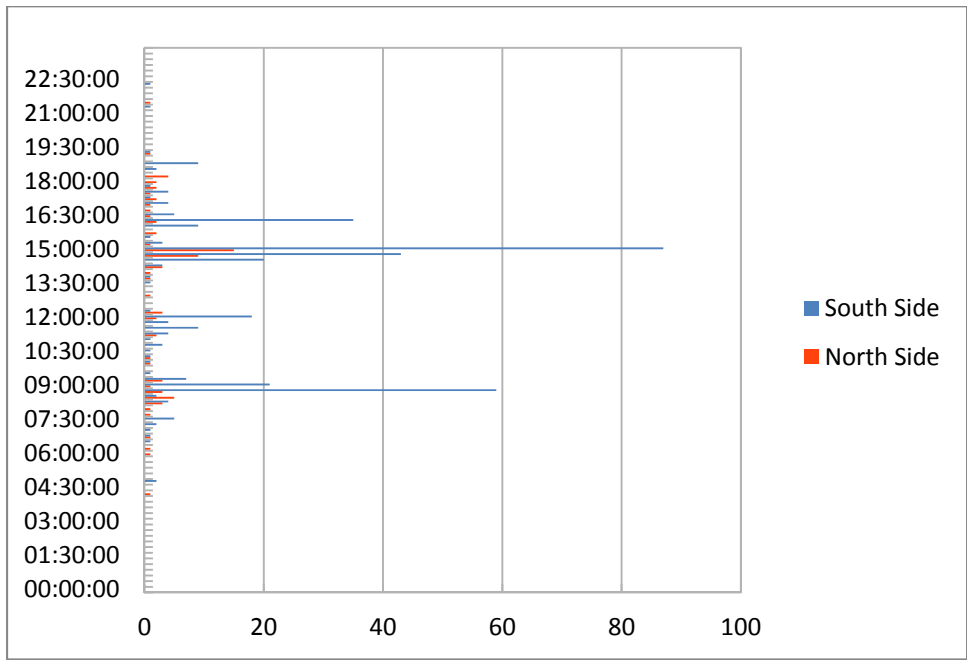


Figure 12. 15-minute pedestrian sidewalk counts at Marquette Rd. crossing.

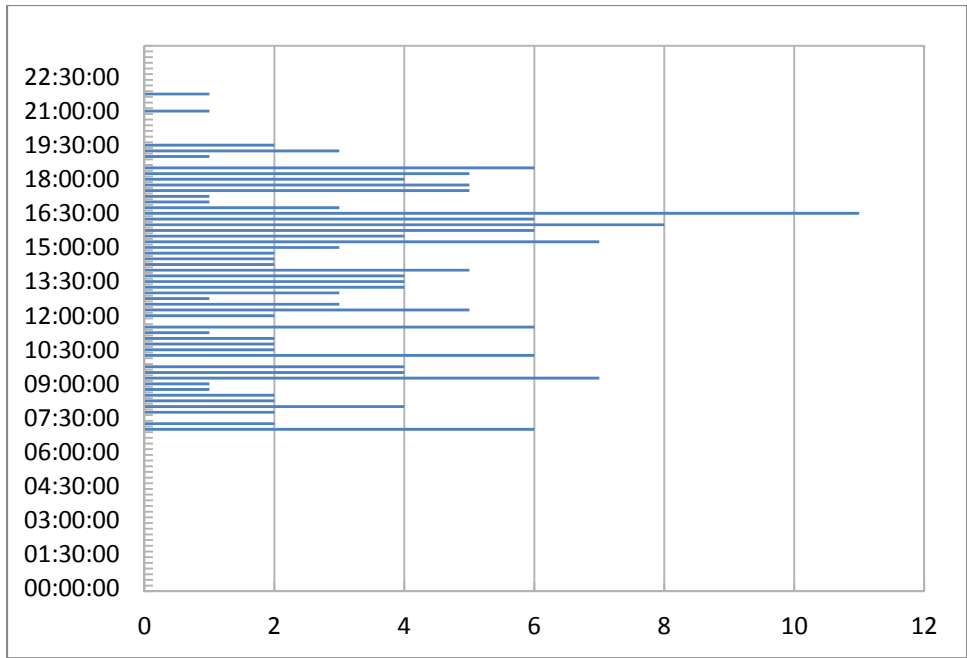


Figure 13. 15-minute pedestrian counts at Osterman Ave. crossing.

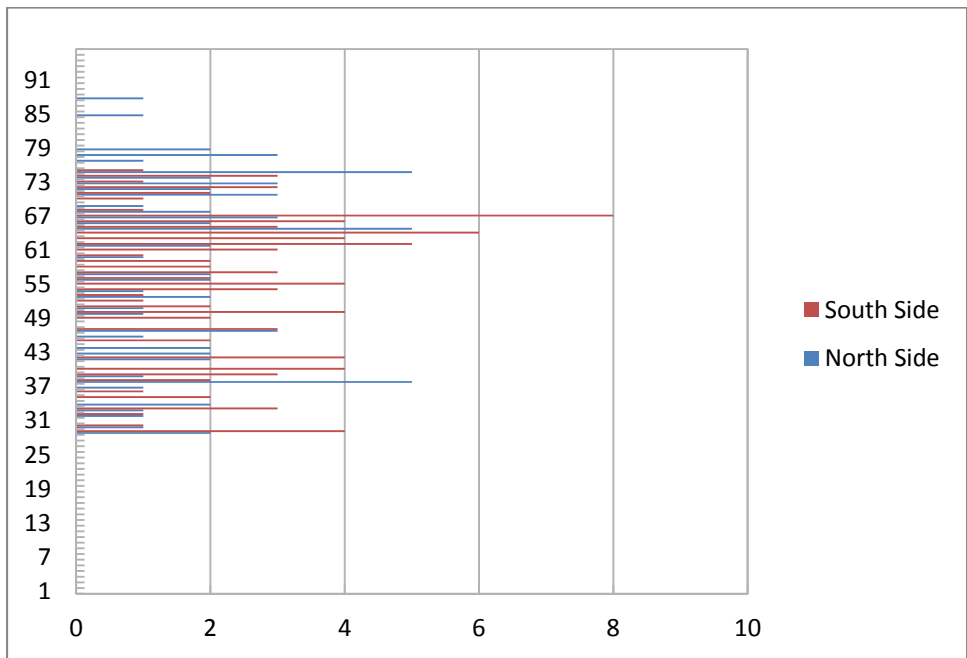


Figure 14. 15-minute pedestrian sidewalk counts at Osterman Ave. crossing.

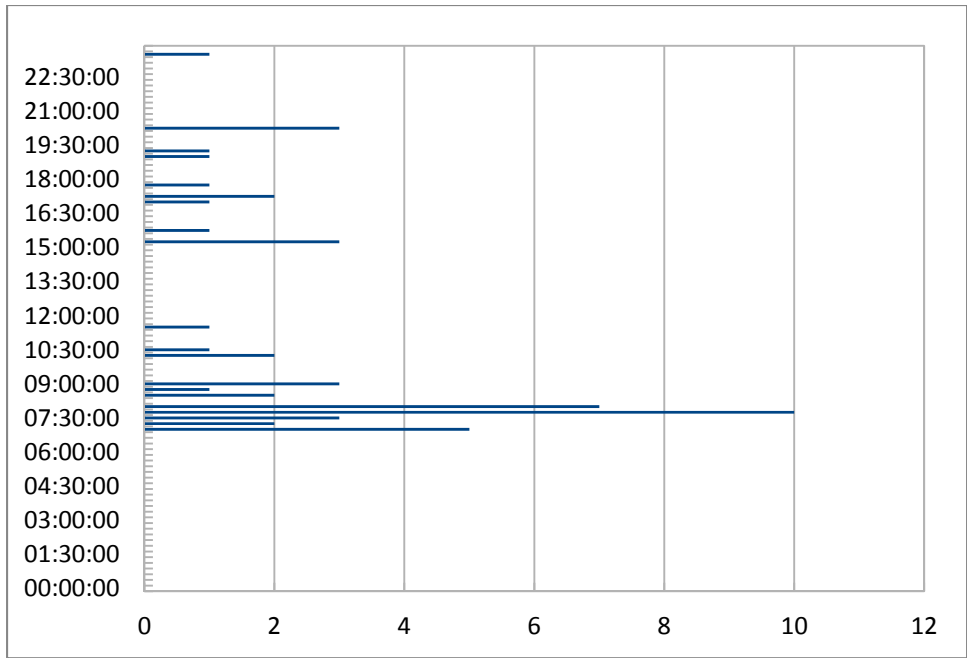


Figure 15. 15-minute pedestrian counts at Park St. crossing.

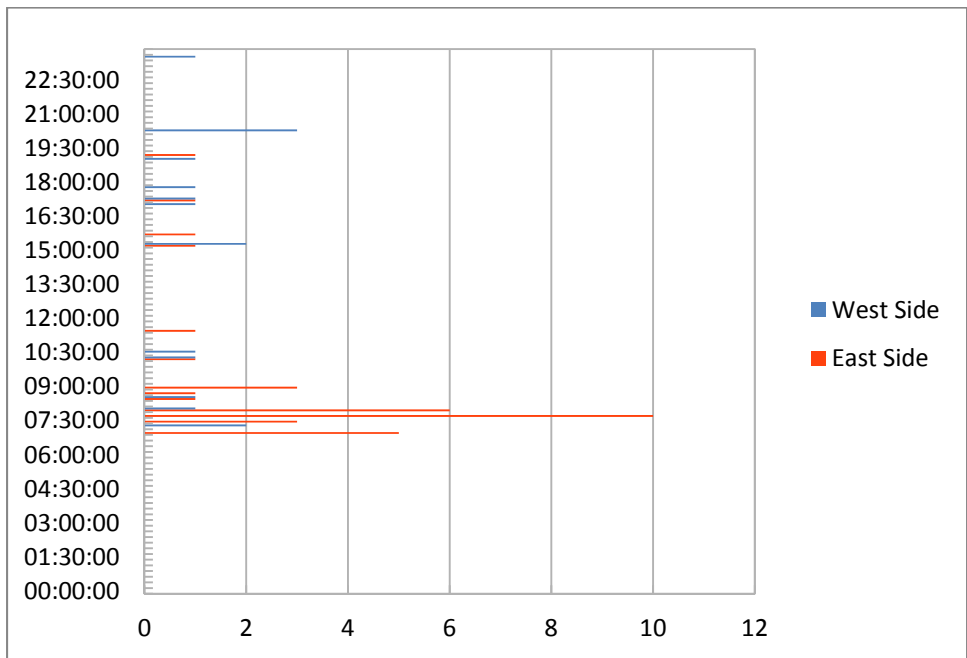


Figure 16. 15-minute pedestrian sidewalk counts at Park St. crossing.

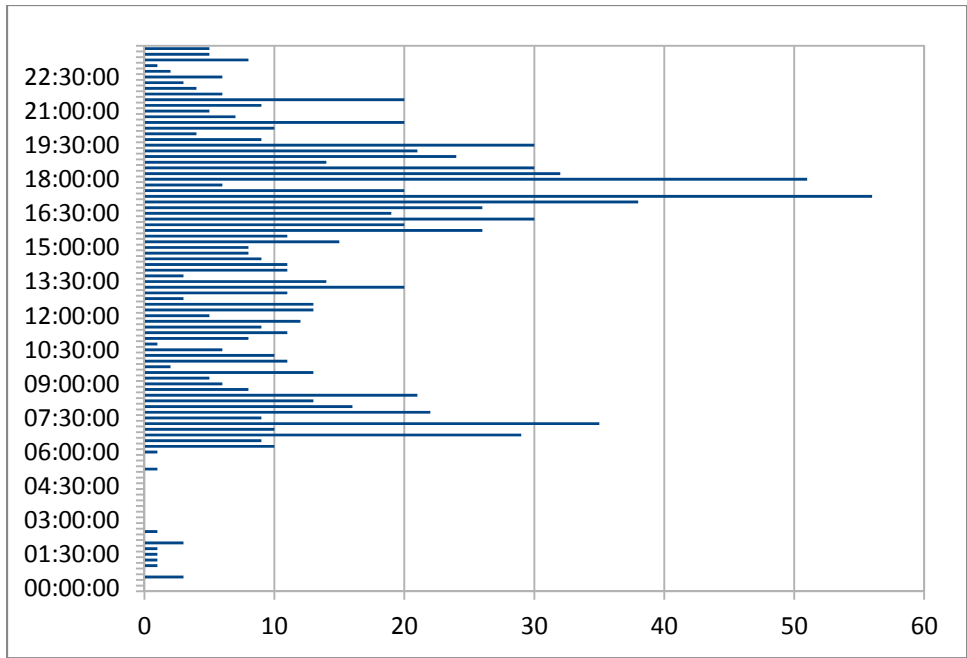


Figure 17. 15-minute pedestrian counts at Villa Park Depot crossing.

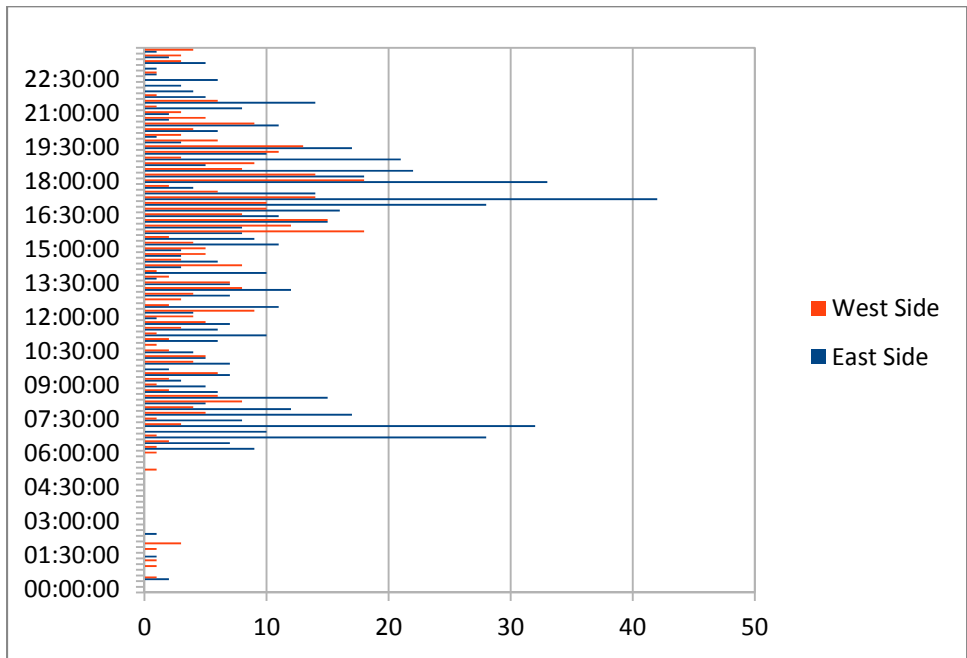


Figure 18. 15-minute pedestrian sidewalk counts at Villa Park Depot crossing.

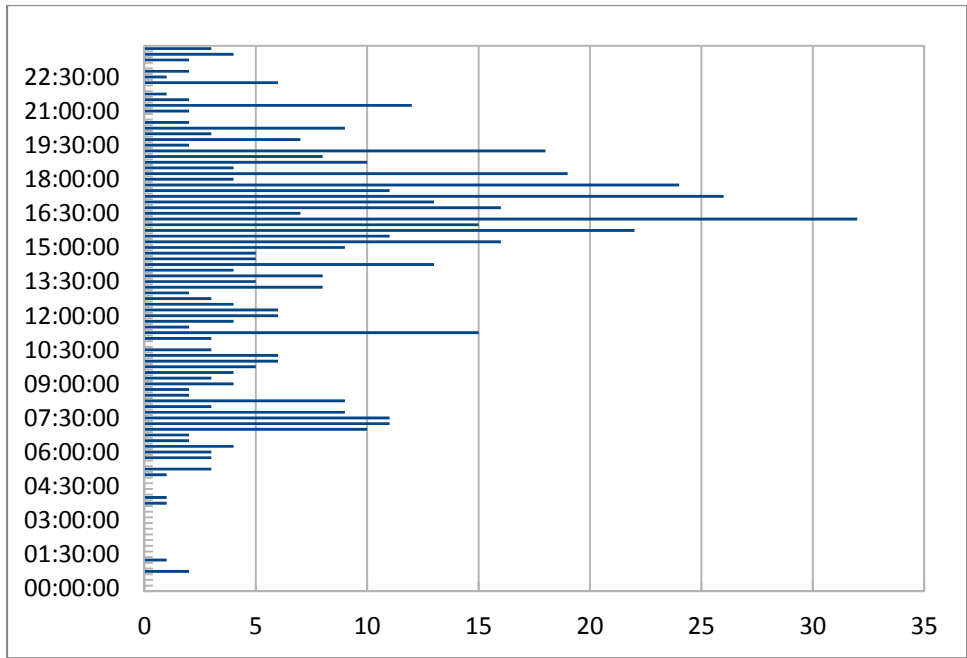


Figure 19. 15-minute pedestrian counts at Elmwood Park Depot crossing.

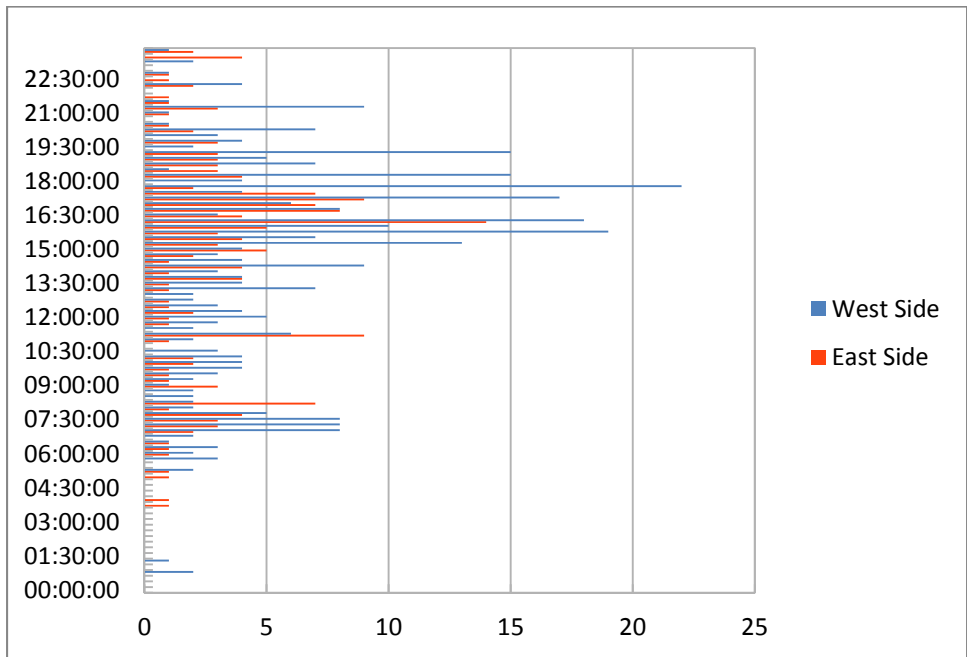


Figure 20. 15-minute pedestrian sidewalk counts at Elmwood Park Depot crossing.

