Transportation Consortium of South-Central States

Tran-SET

Solving Emerging Transportation Resiliency, Sustainability, and Economic Challenges through the Use of Innovative Materials and Construction Methods: From Research to Implementation

Safety of Vulnerable Road Users in Light-Rail Transit Environment

Project No. 20SAOSU06

Lead University: Oklahoma State University

Final Report

July 2021

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16. Abstract

Light-rail transit (LRT), which includes modern streetcars, trolleys, and heritage trolleys, is one of the fastest growing modes of public transportation in the United States. To reduce the cost and complexity of construction, most LRT systems have their tracks placed on city streets, in medians, or in separate at-grade rights-of-way with at-grade crossings. Operating light-rail vehicles (LRVs) along these alignments introduces new conflicts and increases the risk of collisions with vulnerable road users (VRUs) including pedestrians, bicyclists, and electric scooter riders.

This study has two main objectives: (1) to review and evaluate the existing body of knowledge and the state of practice regarding safety of VRUs in LRT environments; and (2) to synthesize this information and package the results in a "Best Practices Resource Guide" and a companion "PowerPoint Presentation" for use in improving the safety of VRUs in existing LRT systems and advancing the professional capacity of transit workforce. Metropolitan Planning Organizations and State DOTs should also benefit from this resource information in the planning and design of new LRT systems.

This report presents a wide range of physical, educational, and enforcement treatments for improving the safety of VRUs in LRT environments. The selection of a particular treatment for use at an LRT grade crossing or station should be based on an engineering study whose scope and complexity depend on local conditions. Factors that should be considered during device selection include 1) pedestrian-LRV collision experience, 2) pedestrian volumes and peak flow rates, 3) train speeds, frequency of trains, number of tracks, and railroad traffic patterns, 4) sight distances available to pedestrians and LRV operators approaching the crossing, and 5) skew angle, if any, of the crossing relative to the LRT tracks.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

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ACRONYMS, ABBREVIATIONS, AND SYMBOLS

APTA	American Public Transportation Association
APS	Accessible pedestrian signals
AWARE	Advanced Warning Alerts for Railroad Engineers
DART	Dallas Area Rapid Transit
DOT	Department of Transportation
FTA	Federal Transit Administration
ft/sec	Feet per Second
IPM	Illuminated in-pavement marker
IVS	Intelligent Video Surveillance
LACMTA	Los Angeles County Metropolitan Transportation Authority
LRT	Light Rail Transit
LRV	Light Rail Vehicle
MPH	Miles per Hour
MPO	Metropolitan Planning Organization
MTA	Maryland Mass Transit Administration
Muni	San Francisco Municipal Railway
MUTCD	Manual on Uniform Traffic Control Devices
NTSB	National Transportation Safety Board
NTD	National Transit Database
OLI	Operation Lifesaver Inc.
TCRP	Transit Cooperative Research Program
TRB	Transportation Research Board
Tri-Met	Tri-County Metropolitan Transportation District of Oregon
UTA	Utah Transit Authority
VRUs	Vulnerable Road Users

EXECUTIVE SUMMARY

Light-rail transit (LRT) – which includes modern streetcars, trolleys, and heritage trolleys – is one of the fastest growing modes of public transportation in the United States. An increasing number of urban and suburban areas across America are turning to light-rail to solve traffic congestion and air quality problems, improve mobility, and spur economic development.

Between 1998 and 2018, annual light-rail vehicle miles increased by 36.8% from 88.5 million to 121.1 million, due to extensions at existing systems and the opening of new systems. During the same time period, the number of light-rail passenger miles increased by 21.2% from 2,093 million to 2,537.6 million. One of the main reasons behind the growing popularity of LRT systems is the ease of fitting them into existing urban and suburban corridors where they can operate in shared rights-of-way or semi-exclusive rights-of-way. To reduce the cost and complexity of construction, the vast majority of LRT systems have their tracks placed on city streets, in medians, or in separate at-grade rights-of-way with at-grade crossings. Operating light- rail vehicles (LRVs) along these at-grade alignments increases the risk of collisions with vulnerable road users (VRUs) including pedestrians, cyclists, electric scooter riders, and motorcyclists.

Because of the lack of outside protective shield, collisions between LRVs and VRUs are more likely to be lethal and result in fatalities and serious injuries. Between 1998 and 2004, on the average, 17% of pedestrian-LRV collisions were fatal, whereas only 2% of vehicle-LRV collisions involved fatalities. Approximately half of the pedestrian-LRV collisions occurred at grade crossing, 10% of collisions occurred at LRT stations, and the remaining 40% of collisions involved trespassing at mid-block locations and exclusive rights-of-way. Collisions at grade crossings are more likely to result in injuries, whereas collisions with trespassers are more likely to be fatal.

Reducing collisions with VRUs and trespassers has been identified by the FTA as the second item of the "Top Ten Safety Action Items" for improving rail transit safety. This research project has two main objectives: (1) to review and evaluate the existing body of knowledge and the state of practice regarding safety of VRUs in LRT environments; and (2) to synthesize this information and package the results into a "Best Practices Guidebook" and a companion "PowerPoint Presentation" that can be incorporated in existing rail safety programs. Managers and safety personnel of existing LRT agencies should find the resource information included in the guidebook and training material useful for improving the safety of VRUs in existing LRT systems and advancing the professional capacity of future transit workforce. Metropolitan Planning Organizations and State DOTs should also benefit from this resource information in the planning and design of new LRT systems.

The safety treatments described in this report were identified through an extensive review of the research literature including national standards such as the MUTCD. In addition, LRT agencies were contacted regarding the implementation of successful solutions to pedestrian safety issues which they face in their daily operations. Safety treatments are grouped into three broad categories: 1) physical (engineering) treatments in the immediate environment surrounding the LRT tracks, 2) public education and awareness programs targeting passengers and people who live, work, or go to school near the LRT alignment, and 3) law enforcement campaigns.

Physical treatments can be passive or active. Passive treatments are static and do not change with the approach of the LRV, whereas active treatments react when an LRV approaches the location. Examples of passive physical treatments include signs that warn pedestrians about grade crossings and pavement markings that delineate the LRV dynamic envelope. Examples of active physical treatments include LRV-activated "Train-Coming" icons, pedestrian auditory icons, and automatic pedestrian gates. Taken as a whole, active treatments are more effective than passive treatments -- the change that occurs in an active device has the effect of generating attention from the intended audience of pedestrians and cyclists. This may add considerably to the effectiveness of the basic message.

Since no two LRT systems are identically similar, and because of the large number of variables to be considered (type of alignment, LRV speed, geometry of grade crossing, etc.), no single standard set of physical treatments is universally applicable to all LRT systems. Deciding on the set of physical treatments that will provide the greatest safety benefits for pedestrians and cyclists in a given LRT environment requires transit and highway agency staff, engineers, and community leaders to engage in problem-solving. The problem-solving effort will often require application of engineering judgment, as well as judgments based upon understanding of pedestrian behavior and the local conditions.

Lack of perception of the risks associated with unsafe actions and behaviors at LRT grade crossings and along LRT right-of-way is one of the primary causes of collisions between VRUs and LRVs. Therefore, public education programs are essential to ensure that VRUs are informed about the dangers associated with LRT operation and how to safely traverse LRT grade crossings. It is also important to address those pedestrians who deliberately trespass on the right-of-way, ignore control devices at grade crossings, and knowingly violate the law. This can take the form of law enforcement and fines, or it can take the form of positive determent (e.g., station signs and advertisements that thank the community for helping the LRT agency make this our safest year).

This report presents examples of education programs and outreach campaigns designed to educate the public about their duties and responsibilities at LRT crossings and along LRT alignments. It also presents available information on police enforcement of LRT safety laws at locations where reports indicate patterns of pedestrian violations.

Depending on local conditions and the types of existing and anticipated safety issues, each LRT agency should conduct a needs assessment to identify the short and long-term public education and outreach goals. This will help the organization establish priorities and utilize resources effectively.

Safety treatments can be applied system-wide or at specific locations (e.g., grade crossings). Individual treatments are often applied as part of an integrated safety improvement package, as some safety issues cannot be addressed by a single treatment alone. However, when a package of treatments is applied, it may be difficult to determine the effect on safety of the individual treatments included in a package. This report presents a decision tree for selecting among VRUs treatments in LRT alignment types with at-grade crossings and LRVs traveling at speeds greater than 35 mph. The decision tree defines the type of VRUs treatments that are recommended based on six criteria (decision points).

1. INTRODUCTION

Light-rail transit (LRT) – which includes modern streetcars, trolleys, and heritage trolleys – is one of the fastest growing modes of public transportation in the United States. An increasing number of urban and suburban areas across America are turning to light-rail to solve traffic congestion and air quality problems, improve mobility, and spur economic development.

Between 1998 and 2018, annual light-rail vehicle miles increased by 36.8% from 88.5 million to 121.1 million, due to extensions at existing systems and the opening of new systems. During the same time period, the number of light-rail passenger miles increased by 21.2% from 2,093 million to 2,537.6 million. Figure 1 illustrates the trend in number of LRT system between 1998 and 2018. The split of transit ridership between rail and roadway modes in 2018 is shown in Figure 2. This robust growth in LRT systems has been driven in part by the Federal Transit Administration's (FTA) fixed guideway capital investment program known as "New Starts".

One of the main reasons behind the growing popularity of LRT systems is the ease of fitting them in existing urban and suburban corridors where they can operate in shared rights-of-way or semi-exclusive rights-of-way. To reduce the cost and complexity of construction, the vast majority of LRT systems have their tracks placed on city streets, in medians, or in separate at-grade rights-of-way with at-grade crossings. According to the National Transit Database (NTD), approximately 86% of the 1321 light-rail track miles in 2004 were constructed at-grade (24). Operating light- rail vehicles (LRVs) along these at-grade alignments introduces new conflicts with the traditional roadway users and increases the risk of collisions with pedestrians, bicyclists, and motorists. The risk of collisions is compounded by a number of factors including:

- LRT has been spreading to nontraditional markets in the South, Midwest, and West where this type of operation is a novelty. Motorists and pedestrians are not typically aware of the potential for and severity of conflicts. This is particularly the case during the first few years of operation of new starts where pedestrians and motorists are at the beginning of the learning curve.
- Modern LRVs are much quieter than the older streetcar designs which makes it difficult for pedestrians to detect an oncoming train.
- Light-rail stations are usually located near major activity centers, feeder-bus stops, and park-and-ride facilities where pedestrian volumes are high.
- Two and sometimes three trains can go through a crossing at the same time. This increases the potential for collision with pedestrians who do not look both ways before crossing the tracks.
- Light-rail expansions often involve high-speed service to suburban/outlying areas and airports with LRVs approaching grade crossings at speeds up to 55 mph depending on alignment type. At these speeds, LRV operators cannot avoid collisions with pedestrians who trespass on the right-of-way, attempt to beat the train, or are inattentive.
- Due to shortage of right-of-way in densely populated areas, portions of some new LRT systems operate jointly with freight trains on shared-use rail corridors or on separate tracks that are constructed close to the freight tracks. Where in the past there were few fairly slow-moving trains per day, there are now fast and quiet LRVs every 20 minutes. This has resulted in increase in the risk of collisions with pedestrians and trespassers.

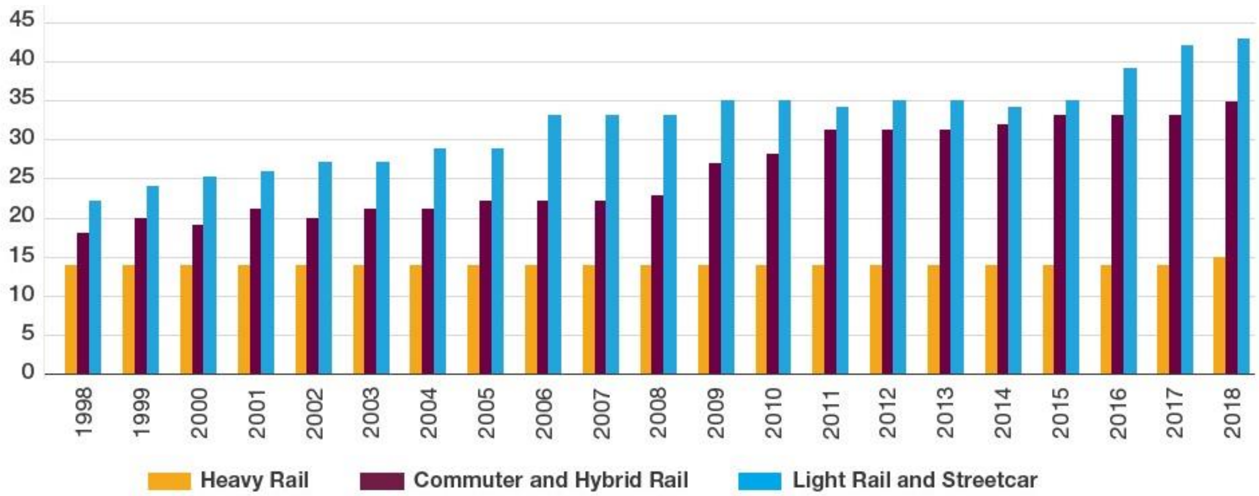


Figure 1. Count of LRT systems, 1988 to 2018 (2020 APTA Fact Book Analysis (51))

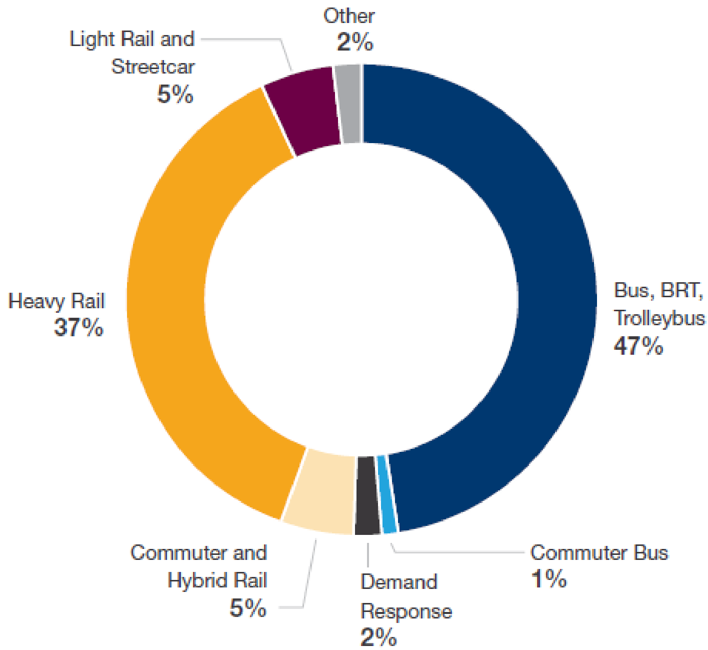


Figure 2. Transit ridership by mode, 2018 (51)

1.1. Vulnerable Road Users

The term "*vulnerable road users*" (VRUs) refers to those most at risk in road traffic, particularly pedestrians, cyclists, electric scooter riders, and motorcyclists as they are unprotected by an outside shield (64, 66). VRUs sustain a greater risk of injury and high casualty rate in any collision against a vehicle and need measures/treatments to reduce the likelihood of such collisions (65). In 2009, the World Health Organization (WHO) reported that half of the 1.2 million transportation-related fatalities occurring each year on the world's transportation systems concern vulnerable road users (VRUs) (63).

Among VRUs, the elderly, the disabled and children are more vulnerable than others because they display a certain amount of task incapability. Elderly people experience gradual decrease in their abilities to cope with complex stimuli and difficult traffic situations and therefore sustain a greater risk of being involved in a collision. Disabled persons have physical, sensory, or mental impairment that affect their response and movements. Therefore, they are more at risk of a collision in difficult traffic situations or on parts of the transportation infrastructure that are not adapted to their needs. Children's abilities to assess traffic hazards and risk evolve with age and remain limited in the first nine to ten years of their life. They are highly at risk in any situation where motorized traffic is heavy, speed is high, or visibility is limited.

As noted, VRUs are heterogeneous groups of people with different characteristics, travel habits and behavioral patterns, having in common their high level of exposure to the risk of collisions in an environment that is often designed to favor vehicular traffic. The scope of this study is therefore wide.

1.2. LRV Collisions

Although LRT systems have an excellent overall safety record compared to other modes of surface transportation, collisions involving LRVs do occur resulting in death and serious injuries. These accidents adversely affect the public image of the safety of LRT systems and the reputation of transit agencies.

Figure 3 illustrates the number of LRV collisions with people and other vehicles that occurred between 1998 and 2004 and the resulting number of fatalities. During this seven-year time period, collisions with other vehicles averaged 314 per year whereas collisions with people averaged 53 per year, excluding suicides. The available data do not distinguish between pedestrians, bicyclists, trespassers, patrons, or employees. The average number of fatalities resulting from collisions with vehicles was 4.57 per year and the average number of fatalities resulting from collisions with people was 9.14 per year.

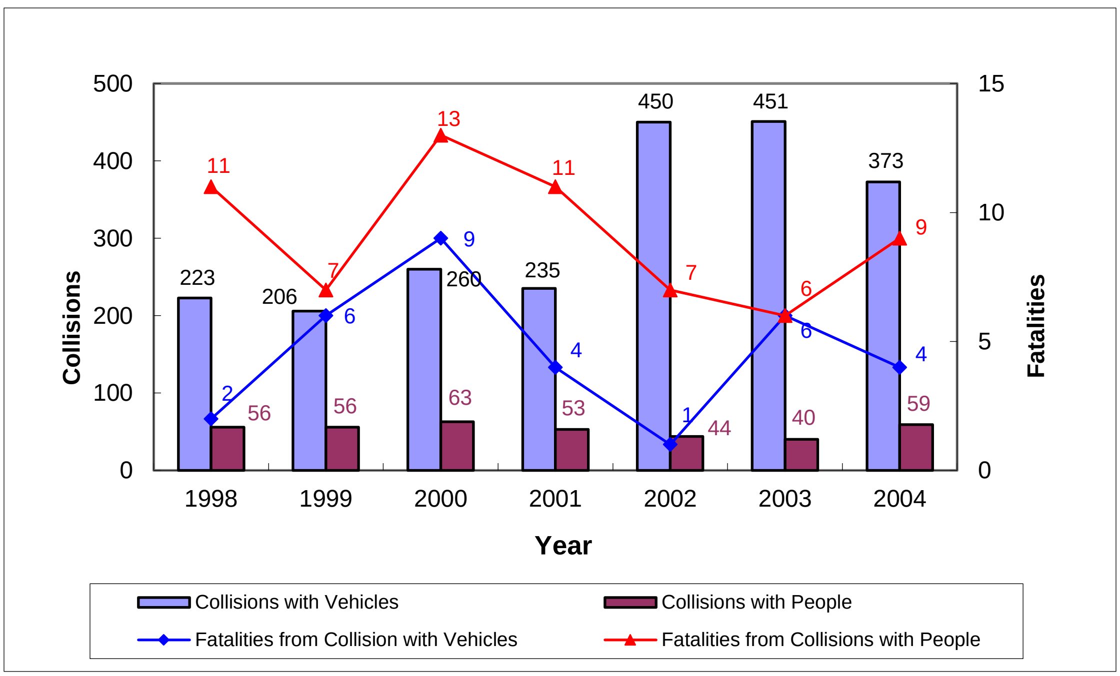


Figure 3. LRT Collisions and Fatalities (No Suicides), 1998-2004

To account for the increase in the number of LRT systems and passenger-miles, Figures 4 and 5 present the average number of collisions per system and the rate of collisions per 100 million passenger-miles. Between 1998 and 2004, LRT systems averaged 14.21 vehicle-LRV collisions and 2.45 pedestrian-LRV collisions per year per system. Using passenger-miles as a measure of exposure, the rate of vehicle-LRV collisions averaged 23.99 and the rate of pedestrian-LRV collisions averaged 4.23 per 100 million passenger-miles per year. It should be noted that substantial variability exists in collision rates among individual LRT systems.

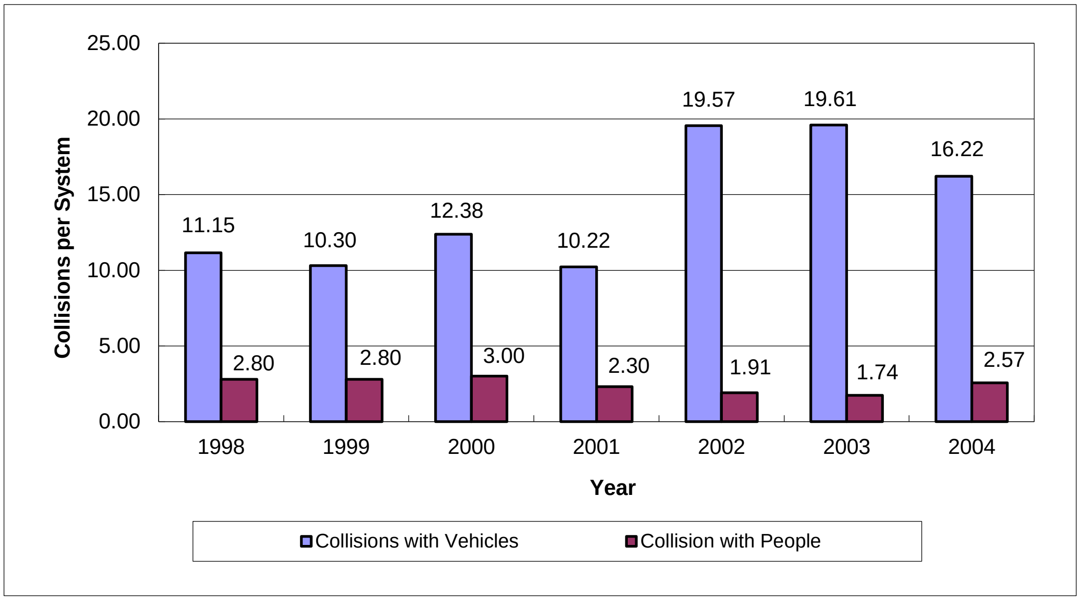


Figure 4. LRT average collisions per system (no suicides), 1998-2004

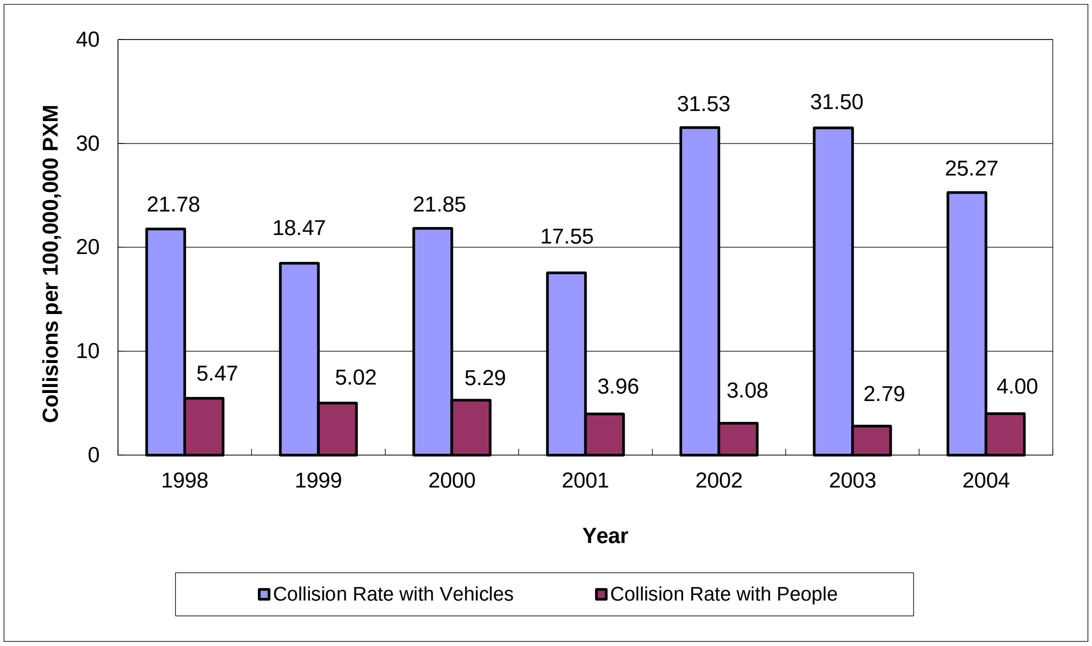


Figure 5. LRT collision rate per 100-million passenger-miles (no suicides) 1998-2004

Although collisions between LRVs and pedestrians are the least common of all LRV collisions, they are more likely to result in fatalities or serious injuries. Figure 6 presents the trend in lethality of LRV collisions between 1998 and 2004. On the average, 17% of pedestrian-LRV collisions were fatal, whereas only 2% of vehicle-LRV collisions involved fatalities.

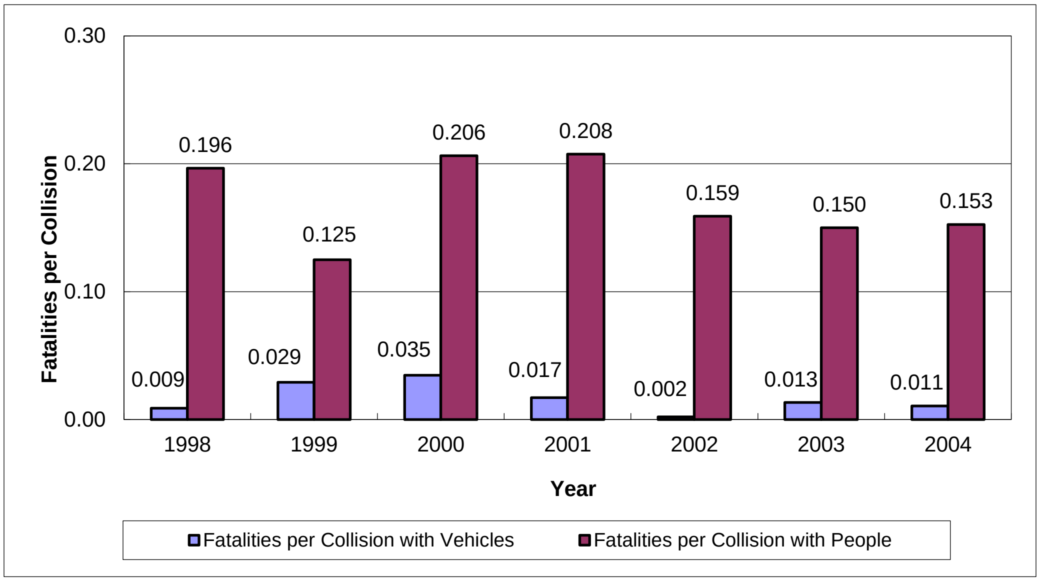


Figure 6. LRT fatalities per collision (no suicides), 1998-2004

The lethality of vehicle-LRV and pedestrian-LRV collisions depends on the speed of the LRV. On route segments with LRV speed greater than 35 mph, 29% of pedestrian and 19% of vehicle collisions resulted in fatalities, respectively (2). At speeds less than 35 mph, 18% of pedestrian-LRV collisions resulted in fatalities, while only 1% of vehicle-LRV collisions involved fatalities (2).

Between 1998 and 2004, approximately half of the pedestrian-LRV collisions occurred at grade crossing, 10% of collisions occurred at LRT stations, and the remaining 40% of collisions involved trespassing at mid-block locations and exclusive rights-of-way (24). Collisions at grade crossings are more likely to result in injuries, whereas collisions with trespassers are more likely to be fatal.

2. OBJECTIVES

The motivation behind this study comes against a backdrop of several converging factors:

- Fatalities resulting from pedestrian-LRV collisions continue to represent a significant portion of all collision-related fatalities in LRT systems (25).
- Considerable expansion of existing LRT systems.
- The "New Starts" capital investment program is swamped with applications.
- Reducing collisions with pedestrians and trespassers has been identified by the FTA as the second item of the "Top Ten Safety Action Items" for improving rail transit safety (27). Table 1 presents the FTA's 10 most wanted list.

This research project has two main objectives: (1) to review and evaluate the existing body of knowledge and the state of practice regarding safety of VRUs in LRT environments; and (2) to synthesize this information and package the results in a "Best Practices Guidebook" and a companion "PowerPoint Presentation" that can be incorporated in rail safety programs. Managers and safety personnel of LRT agencies should find the resource information included in the guidebook and training material useful for improving the safety of VRUs in existing LRT systems and building the professional capacity of future transit workforce. Metropolitan Planning Organizations and state DOTs should also benefit from this resource information in the planning and design of new LRT systems.

Table 1. FTA top 10 safety action items (27)

1. Reducing Collisions with Other Vehicles
2. Reducing Collisions with Pedestrians and Trespassers
3. Improving Compliance with Operating Rules
4. Reducing the Impacts of Fatigue on Transit Workers
5. Reducing Unsafe Acts by Passengers in Transit Stations
6. Improving Safety of Transit Workers
7. Improving Safety for Passengers with Disabilities
8. Removing Debris from Tracks and Stations
9. Improving Emergency Response Procedures
10. Improving Safety Data Acquisition and Analysis

3. LITERATURE REVIEW

The safety of vulnerable road users (VRU) in LRT environments has been the subject of a number of research projects and publications. Following are the most notable research reports on this subject:

TCRP Report 17: Integration of Light-Rail Transit into City Streets (1) – Transit Cooperative Research Program Report 17 documents the results of a study on the safety and operating experience of ten North American LRT systems operating in shared rights-of-way (on, adjacent to, or across city streets or mall) at low to moderate speeds that do not exceed 35 mph. The report concludes that although LRT systems are generally safer than the motor-vehicle highway system, collisions remain a significant problem. The majority of collisions occur due to driver or pedestrian inattention, disobedience of traffic laws, and confusion about the meaning of traffic control devices. Traffic control treatments at light-rail grade crossings vary from system to system and sometimes within the same system.

TCRP Report 69: Light-Rail Service: Pedestrian and Vehicular Safety (2) – Transit Cooperative Research Program Report 69 presents the results of a study of LRT systems that contain segments operating at speeds greater than 35 mph. The results indicate that most collisions occur on semi-exclusive and non-exclusive alignments where LRVs travel below 35 mph. However, the percentage of fatalities among motorists and pedestrians involved in collisions with LRVs traveling at higher speed is significantly higher than the percentage of motorist and pedestrian fatalities involving LRVs traveling at speeds below 35 mph. A number of grade crossing treatments, in addition to automatic gates and flashing lights, are recommended to raise driver and pedestrian awareness of approaching trains including second train approaching signs, pedestrian Z-crossings, etc.

TCRP Research Results Digest 84: Audible Signals for Pedestrian Safety in Light-Rail Transit Environments (7) – This digest provides guidelines for the application of audible signals for pedestrian safety in LRT environments. The guidelines include descriptions of audible signal systems and associated operating procedures, their integration with other LRT grade crossing measures, criteria for their use, and their effectiveness and limitations. The guidelines are organized by the location of audible warning devices (on- board the LRV or wayside audible devices) and alignment type.

TCRP Research Results Digest 51: Second Train Coming Warning Sign: Demonstration Projects (5) – This report summarizes the results of two demonstration projects in Maryland and California concerning second-train- coming warning signs for light-rail transit systems. The demonstration projects were conducted at the Maryland Mass Transit Administration (MTA) and the Los Angeles County Metropolitan Transportation Authority (LACMTA) and were administered by the Federal Transit Administration (FTA) with funding through TCRP Project A-5A, "Active Train Coming/Second Train Coming Sign Demonstration Project."

The effectiveness of the second train warning sign was evaluated using two approaches: 1) before and after data regarding risky crossings by pedestrians were collected and analyzed, and 2) an intercept survey of pedestrians to gauge pedestrian awareness and understanding of the second train warning sign. The demonstration project found that the warning sign was effective in reducing risky behavior by pedestrians.

TCRP Report 137: Improving Pedestrian and Motorist Safety Along Light- Rail Alignments (10) – This report addresses pedestrian and motorist behaviors contributing to collisions with LRV and explores available mitigating measures designed to improve safety along LRT alignments. The report also includes suggestions to facilitate the compilation of LRV accident data in a coordinated and homogeneous manner across LRT systems. Finally, the report provides a catalog of existing and innovative devices, treatments, and practices for improving safety.

TCRP Project J-6 Task 65 Report: Operation of Street Running Light-Rail at Higher Speeds (4) – The objective of this TCRP project is to identify the safety and operational factors involved in traffic control using crossing gates versus traffic signals, possibly in conjunction with supplemental safety measures, and to define traffic control treatments that would potentially allow for faster than 35-mph operation without use of crossing gates. This report documents issues and options associated with the potential for operating street-running light-rail transit at higher speeds for consideration in potential revisions to Part-8 "Traffic Control for Railroad and Light-Rail Transit Grade Crossings" of the Manual on Uniform Traffic Control Devices (MUTCD).

Effects of Pedestrian Treatments on Risky Pedestrian Behavior, Transportation Research Record 1793 (15) – This paper describes a study conducted at the Tri-Met LRT System in Portland, Oregon to evaluate the effects of audible devices on risky pedestrian behavior. In a demonstration project, Tri-Met installed pedestrian audible devices at various locations. The audible devices announce the message "Train Approaching, Look Both Ways" in both Spanish and English when a train activates the crossing control devices. The results of the device were mixed based on the type of behavior observed.

Pedestrian Warning and Control Devices, Guidelines and Case Studies, Transportation Research Record 1762 (16) – This paper provides recommendations on how to identify potentially hazardous crossings and appropriate treatments. The paper identifies four basic factors that govern the level of pedestrian safety at crossings. These factors are:

- Pedestrian awareness of the crossing,
- Pedestrian path across the trackway,
- Pedestrian awareness of the approaching LRV,
- Pedestrian understanding of the potential hazards at grade crossing.

Each factor is discussed, and case studies are presented where innovative treatments have been used to increase pedestrian safety at LRT grade crossings.

In addition to the above TCRP research projects and TRB publications, the FTA has forged a partnership with Operation Lifesaver (OLI) to address light-rail safety public education and outreach. Since 2004, OLI has been testing public education materials at light-rail transit agencies across the country for improving safety awareness and outreach efforts. These materials, which are now available to all LRT systems, free of charge, have been designed to meet specific light-rail transit system needs.

3.1. LRT Alignment Types

Depending on the potential for conflicts with and the level of exposure to motor vehicles and/or pedestrians, LRT alignments are typically grouped into one of the following three types:

Type-a: Exclusive Alignments – An LRT right-of-way that is grade-separated or protected by a fence or traffic barrier. Motor vehicles, pedestrians, and bicycles are prohibited within the right-of-way. This type of alignment does not have grade crossings, thereby eliminating operating conflicts and maximizing safety and operating speeds. Subways and aerial structures are included within this group.

Type-b: Semi-exclusive – An LRT alignment that is in a separate right-of-way or along a street or railroad right-of-way where motor vehicles, pedestrians, and bicycles have limited access and cross at designated grade crossings only. Operating speeds on segments that do not have automatic crossing gates are governed by vehicle speed limits on the streets or highways. On segments of this type of alignment where the right-of-way is fenced, operating speeds are maximized, but these higher speeds are typically maintained only for short distances, often on segments between grade crossings.

Type-c: Non-exclusive – An alignment where LRT operates in mixed traffic with all types of road users. This includes streets, transit malls, and pedestrian malls where the right-of-way is shared, resulting in higher levels of operating conflicts and lower operating speeds. These alignments are typically found in downtown areas where there is a willingness to forgo operating speeds in order to access areas with high population density and many potential riders.

The above classification system is useful in selecting the appropriate treatments to improve the safety of VRUs along LRT alignments.

This study is concerned with the conflicts between LRVs and VRUs which are typically found in type-b and type-c alignments. It does not address type-a alignments which are designed to eliminate pedestrian and motor vehicle interactions with LRVs, except in unusual circumstances such as trespassing.

Table 2 presents the LRT alignment subcategories set out in TCRP Report 69 (2). Examples of the different alignments are shown in Figures 7 through 19.

Based on safety considerations, TCRP Report 17 suggested the following sequence for LRT route alignment choices in the order of desirability (1):

- Exclusive alignment (Type a),
- Separate right-of-way (Type b.1),
- Median alignment protected by barrier curbs and/or fences (Types b.2 and b.3),
- Median alignment protected by mountable curbs and striping (Type b.4),
- Operation in reserved transit malls or pedestrian areas (Types b.5, c.2, and c.3), and
- Operation in mixed traffic (Type c.1).

In addition to safety, other considerations that may be addressed in evaluating LRT alignments include speed, accessibility, and construction cost. For example, Type-a alignments allow LRVs to travel at high speeds for long distances but are costly and may be difficult for riders to access from surrounding areas. These types of alignment are most often served by park-and-ride lots or other transit modes.

Type-b and Type-c alignments create more conflicts with motor vehicles and pedestrians, but they are less expensive to construct and offer the advantage of providing more direct access to a variety of land uses.

Table 2. LRT alignment classification (2)

Class	Category	Description of Access Control
Exclusive	Type a	Fully grade separated or at-grade without crossings
Semi-exclusive	Type b.1	Separate right-of-way
Semi-exclusive	Type b.2	Shared right-of-way, protected by barrier curbs and fences (or other substantial barriers)
Semi-exclusive	Type b.3	Shared right-of-way, protected by barrier curbs
Semi-exclusive	Type b.4	Shared right-of-way, protected by mountable curbs, striping and/or lane designation
Semi-exclusive	Type b.5	LRT-pedestrian mall adjacent to parallel roadway
Non-exclusive	Type c.1	Mixed traffic operation
Non-exclusive	Type c.2	Transit-only mall
Non-exclusive	Type c.3	LRT-pedestrian mall

Figure 7. Example of type-a exclusive alignment
Salt Lake City, Sandy Line, UT

Figure 8. Typical type b.1 alignment
New Jersey Transit, NJ

Figure 9. Median running type b.2 semi-exclusive alignment
M-line, San Francisco MUNI, CA

Figure 10. Typical Type b.2 Station
Minneapolis Metro Transit, MN

Figure 11. Pedestrian Crossing of Type b.2 Median Running Alignment
New Jersey Transit, NJ

Figure 12. Type b.3 Alignment with Textured Surface and Drainage
New Jersey Transit, NJ

Figure 13. Type b.3 Alignment with Barrier Curbs
Santa Clara SCVTA, CA

Figure 14. Type b-4 Semi-exclusive Alignment - Rumble Strip and Pavement Markings Salt Lake City, UT

Figure 15. Trains Passing on Type b.4 Alignment Minneapolis Metro Transit, MN

Figure 16. Intersection on Semi-exclusive Alignment
San Francisco MUNI, CA

Figure 17. Type c.1/b.3 Alignment
New Jersey Transit, NJ

Figure 18. Type c.1 downtown alignment
Minneapolis Metro Transit, MN

Figure 19. Type c.3 alignment with pedestrian mall
Santa Clara SCVTA, CA

3.2. Common LRT-VRUs Safety Issues

Understanding the safety issues encountered by VRUs in LRT environments is a basic step in the selection of safety treatments. Table 3 summarizes the common VRUs safety issues documented in TCRP Report 17 (1), TCRP Report 69 (2), TCRP Report 137 (10), and the National Transit Database (NTD).

Table 3. Common pedestrian-related safety problems

Source	Pedestrian-Related Safety Problems
TCRP Report 17	• Trespassing on tracks. • Jaywalking. • Station and/or cross-street access.
TCRP Report 69	• Limited sight distance at pedestrian crossing. • Pedestrians dart across LRT tracks without looking.
TCRP Report 137	• Motorist, cyclist, and pedestrian inattention. • Motorist, cyclist, and pedestrian confusion. • Lack of appropriate physical separation between motorists, cyclists, pedestrians, and the LRV. • Risky behavior by motorists and pedestrians. • Operator error or lack of information.
NTD	• Rushing to catch trains or get across intersections. • Ignoring audible and/or visual warnings at grade crossings. • Distractions, such as cell phones and headsets. • Not paying attention in transit malls. • Intoxication. • Trespassing.

TCRP Report 17 (1) explored pedestrian-related problems at 10 LRT systems with operating speeds of less than 35 mph along alignment types b.3 through and c.1 through c.3. The 10 systems surveyed were located in Baltimore, Boston, Buffalo, Calgary (Canada), Los Angeles, Portland, Sacramento, San Diego, San Francisco, and San Jose. These systems provide a portion of their operation on-street in mixed traffic, shared rights-of-way (in which LRVs operate on, adjacent to, or across city streets at low to moderate speeds), and LRT pedestrian malls. The common pedestrian-related safety problems were:

- Trespassing on tracks at stadium stations after events.
- Jaywalking between marked crossing locations (i.e., mid-block, at stations, etc.).
- Station and/or cross-street access.

TCRP Report 69 (2) investigated pedestrian-related problems at 11 LRT systems operating on semi-exclusive rights-of-way at speeds greater than 35 mph. These LRT systems were located in Baltimore, Calgary (Canada), Dallas, Denver, Edmonton (Canada), Los Angeles, Portland, St. Louis, Sacramento, San Diego, and San Jose. A survey carried out as part of the study found a wide variation in operating practices, safety issues and concerns, accident experience, and innovative safety treatments among the LRT systems. This finding reflected the different environments and contexts at LRT crossings, and the different warning systems and traffic control devices found at LRT crossings in the different systems and among different segments of the same system.

The large majority of the grade crossings and LRT alignments examined were equipped with flashing lights and automatic gates. The common pedestrian- related safety problems were:

- Limited sight distance at pedestrian crossing; and
- Pedestrians dart across LRT tracks without looking.

TCRP Report 137 (10) examined pedestrian-related problems at five LRT systems in Minneapolis, New Jersey, Salt Lake City, San Francisco, and Santa Clara. The report listed the following five top areas of safety concern which were common themes noted in almost all communications with LRT agency staff:

- Motorist, cyclist, and pedestrian inattention,
- Motorist, cyclist, and pedestrian confusion,
- Lack of physical separation between motorists, cyclists, pedestrians, and the LRV,
- Risky behavior by motorists and pedestrians,
- Operator error or lack of information.

The project team suggested that the above five top areas of safety concern should serve as a basic checklist for addressing safety problems along LRT alignments.

Analysis of the 2002 and 2003 pedestrian-LRV collision data included in the NTD indicates that careless, risky, and inattentive behaviors are frequent causes of pedestrian-LRV collisions (7). Although the NTD does not include a root-cause analysis of each collision, the information included in the "incident description" and "event description" parts of the database can be used to determine the contributing factors that led to collisions. Common contributing factors include:

- Rushing to catch trains or get across intersections - This behavior occurs primarily near stations or on station platforms.
- Ignoring audible and/or visual warnings at grade crossings - In many instances, pedestrians purposefully walked around crossing gates or disregarded other active warnings. The reasons for this behavior are not known.
- Distractions - The use of cells phones and headsets were contributing factors in four of the accidents.
- Not paying attention in transit malls - Although most of these incidents do not result in serious injury and therefore were not reported in the NTD, several agencies indicated that this is their most common type of accident. For instance, people walk in front of trains as they leave the station even after an audible warning is sounded.
- Intoxication -At least five serious accidents were attributed to intoxicated pedestrians.
- Trespassing. There were several accidents near tunnel portals or within exclusive rights-of-way.

3.3. VRUs Characteristics and Behavior

Understanding the characteristics and behavior of VRUs is important for identifying effective measures for accommodating them safely along LRT alignments. The Manual on Uniform Traffic Control Devices (MUTCD) defines a pedestrian as a person on foot, in a wheelchair, on skates, or on a skateboard (28). Persons afoot may use walkers or canes, be pushing a stroller or delivery dollies, or be assisting a youngster on a tricycle.

Everyone is a pedestrian at one time or another and all travelers are pedestrians at some point in their trip. While many pedestrians are fit and healthy, have satisfactory vision and hearing, pay attention to their surroundings, and are not physically handicapped, this is not the case for all pedestrians. Some pedestrians may have a vision or cognitive disability, be distracted, or lost.

Given the diversity of VRUs, safety treatments should consider the wide range of their needs, including those of children, older pedestrians, and pedestrians with mobility aids. This section introduces basic pedestrian characteristics and behaviors including:

- Common pedestrian behavior in LRT environments,
- Common characteristics of pedestrians,
- Walking speed,
- Spatial needs,
- Pedestrian perception of train speed and distance,
- Level of service (LOS) standards for pedestrian facilities,
- Pedestrians with disabilities.

3.3.1. VRUs Behavior in LRT Environments

Following are key research findings of VRUs behavior in LRT alignments:

- Most pedestrians take the shortest path between where they are and where they want to go. Poorly designed crossings often result in pedestrians using informal paths through the right-of-way at locations without pedestrian safety treatments. Therefore, LRT grade crossing facilities should be located at the most direct crossing locations.
- Pedestrians concerned about reaching the station before the train arrives. Therefore, pedestrians running late may take more risks than they typically would under normal conditions.
- Pedestrians have a minimal threat of law enforcement.
- Many pedestrians have a sense of control over the right-of-way.
- Pedestrians interpret signs and signals at crossings differently.
- Many pedestrians trespass onto the right-of-way (jaywalking or crossing at locations that do not have pedestrian crossing facilities).
- Pedestrians ignore warning devices such as flashing lights and bells.
- Pedestrians tend to look down not up.
- Pedestrians step into the LRT right-of-way to get around people waiting at a station.
- Pedestrians cross the tracks after a train had left the station without looking if a second train is coming.
- Pedestrians are inattentive and not always alert to their surroundings.
- Pedestrians do not stop or slow down before entering a crossing.
- Pedestrians fail to look both ways before crossing tracks.
- Pedestrians enter a crossing after a train has passed but before the gates fully ascend.
- Pedestrians stand too close to the tracks as the train approaches.
- Pedestrians and bicyclists routinely cross LRT tracks behind automatic gate mechanism while activated.
- Pedestrians are often confused due to contra flow operations of train with respect to motor vehicles.

The physical improvements listed in section 5 of this report can help reduce the risky pedestrian behavior along LRT alignments. The public education and outreach programs discussed in section 5 are necessary compliments to physical treatments and control devices.

3.3.2. Common Pedestrian Characteristics

Pedestrians vary widely in their physical and cognitive abilities. For example, children's heights and varying cognitive abilities at different ages need to be considered, as do declines in speed of reflexes, hearing and sight among older pedestrians. Table 4 summarizes key pedestrian characteristics that should be considered in developing and implementing treatments for enhancing pedestrian safety in LRT environments.

The age, physical ability, and cognitive capacity of pedestrians influence how they behave and react when walking. Table 5 lists some of the common characteristics of pedestrians of various ages.

3.3.2.1. Walking Speed

An important consideration in designing pedestrian facilities is the speed at which pedestrians walk. Walking speeds range from approximately 2.5 to 6.0 ft/sec (32). The MUTCD recommends a normal walking speed of 4.0 ft/sec for calculating pedestrian intervals for traffic signals (28).

Pedestrian age has the greatest effect on walking speed -- the very young and the very old tend to walk more slowly than other pedestrians. Eubanks and Hill found that walking speeds increase gradually until about the age of 10 and remain fairly steady until age 50, decreasing somewhat for pedestrians over 60 (36). Impairments may also slow the walking rate. In areas where large numbers of children, older pedestrians, or pedestrians with physical impairments are expected, a slower walking speed such as 3.0 ft/sec should be considered for design.

Other factors that impact walking speed include weather (air temperature, rain, snow, ice), route characteristics (gradient, surfacing), pedestrian density, time of day, and trip purpose. Pedestrians going to and from work, using the same facilities day after day, walk at higher speeds than shoppers. Walking speeds are also typically faster at midblock crossings than at intersections.

3.3.2.2. Pedestrian Perception of Train Speed and Distance

At passive grade crossings, it may be difficult for a pedestrian to accurately gauge the speed and arrival time of an approaching train. Once the train is detected, the pedestrian's perceptual judgments of train velocity and distance will guide the pedestrian in deciding whether it is safe to proceed across the tracks.

Human factors research at grade crossings describes illusions regarding train size that can mislead a pedestrian/motorist about the train's velocity (39). First, the larger an object, the more slowly it appears to be moving; thus, because the train locomotive is a large object, it may appear to be moving more slowly than it actually is, causing the pedestrian/driver to overestimate the amount of time available to safely clear the crossing. Second, when a pedestrian/driver is stopped at a crossing and looking down the tracks, the principal perceptual cue available to the person is the rate of growth of the train's apparent size in the visual field. This apparent rate of growth is not linear; it is hyperbolic. When the train is at a distance, the apparent rate of growth for the object is slow, thereby giving the impression of slow speed. However, as the train gets closer, the increase in the size of the object in the visual field accelerates. This is shown in Figure 20 which presents images taken from a computer simulation produced by the National Transportation Safety Board

Table 4. Physical and cognitive characteristics of pedestrians (35, 43, 44, 45)

How pedestrians differ	Affecting	Impacting on
Height	• Ability to see over objects. • Ability to be seen by others.	• Sight lines and sight triangles.
Speed of reflexes	• Inability to avoid dangerous situations quickly.	• Crossing opportunities.
Stamina	• Journey distance between rests.	• Resting places.
Visual perception	• Ability to scan the environment and tolerate glare.	• Sign legibility. • Detecting curbs and crossing locations. • Detecting hazards. • Tactile paving.
Attention span and cognitive abilities	• Time required to make decisions. • Difficulties in unfamiliar environments. • Inability to read or comprehend warning signs.	• Positive direction signage. • Streetscape 'legibility'. • Use of symbols.
Balance and stability	• Potential for overbalancing.	• Providing steps and ramps • Curb height • Gradients • Surface condition
Fear for personal safety and security	• Willingness to use all or part of a route.	• Lighting. • Surveillance. • Pedestrian densities. • Traffic speed and density.
Manual dexterity and coordination	• Ability to operate complex mechanisms.	• Pedestrian-activated traffic signals.
Accuracy in judging speed and distance	• Risky crossing movements.	• Provision of crossing facilities.
Difficulty identifying the direction of sounds	• Audible warning and clues to traffic being missed.	• Need to reinforce with visual information.
Energy expended in movement	• Walking speed.	• Crossing times.

(NTSB) (62). The Figure illustrates the apparent change in object size as seen by a person stopped at a crossing and a train approaches the crossing at 40 mph.

For example, a 10-ft-wide by 15-ft-tall LRV will occupy a visual angle of 0.43° when it is 2,000 feet from the observer. As the train reaches 1,000 feet, the visual angle has doubled to 0.86°. When the train is even closer to the observer, the visual angle also doubles even though the train traverses less distance: the visual angle grows from 3.43° to 6.84° when the train travels from 250 feet to

125 feet from the observer. Pedestrians and drivers tend to be effective at estimating the speed of the LRV when it is closest because the change in visual angle is rapid. However, pedestrians/drivers tend to decide on the safety of proceeding across the tracks when the LRV is at greater distances, when the change in visual angle is slow and they are more likely to underestimate the train's speed.

Table 5. Common pedestrian characteristics by age group (37)

Age	Characteristic
0-4	• Learning to walk. • Requires constant parental/adult supervision. • Developing peripheral vision and depth perception.
5-8	• Increasingly independent, but still requires supervision. • Poor depth perception.
9-13	• Sense of invulnerability. • Poor judgment. • Susceptible to "dart out" type crashes.
14-18	• Improved awareness of traffic environment. • Poor judgment.
19-40	• Active, fully aware of traffic environment.
41-65	• Reflexes begin to slow.
65+	• May cross LRT grade-crossings with difficulty. • May have poor vision. • May have difficulty in hearing approaching trains. • High fatality rate if involved in a collision.

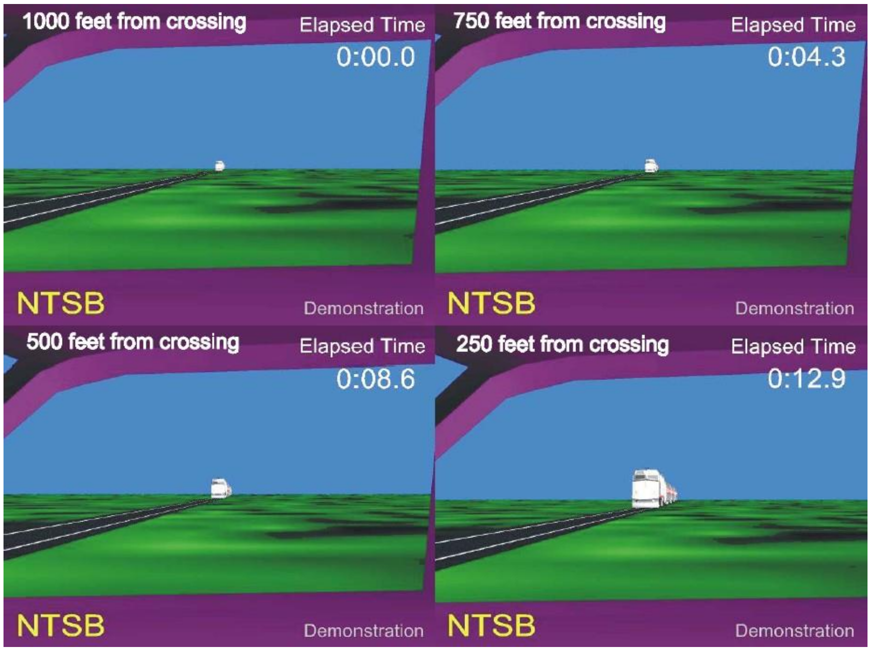


Figure 20. Pedestrian perception of train speed and distance (62)

3.3.3. Pedestrians with Disabilities

Good pedestrian design should account for the needs of all potential users, including those with physical or mental limitations:

Mobility-impaired pedestrians - Mobility-impaired pedestrians are commonly thought of as using devices to help them to walk, ranging from canes, sticks and crutches to wheelchairs, walkers, and prosthetic limbs. However, a significant proportion of those with mobility impairments do not use any visually identifiable device (35). Table 6 summarizes key characteristics of mobility-impaired pedestrians.

Sensory-impaired pedestrians - Sensory impairment is often mistaken as being a complete loss of at least one sense, but a partial loss is much more common. Vision impairment mainly affects pedestrians' abilities, although to some extent hearing can have an effect (35). Table 7 summarizes key characteristics of sensory-impaired pedestrians.

Wheeled pedestrians - Wheelchair and mobility scooter users can legitimately use the pedestrian crossing, but in many ways their characteristics are very different from those of walking pedestrians. Table 8 summarizes key characteristics of wheeled pedestrians.

Table 6. Characteristics of mobility-impaired pedestrians (35, 43, 44, 45)

Characteristic	**Resulting in**	**Impacting on**
Extra energy expended in movement	Slower walking speed	• Crossing time • Sight triangles
Use of mobility aids	Increased physical space and good surface quality needed	• Crossing width • Crossing surface condition • Obstructions
Decreased agility, balance and stability	Difficulties in changing level	• Provision of steps/ramps • Curb height • Gradients • Handrails • Surface quality
Reduced manual dexterity and coordination	Reduced ability to operate complex mechanisms	• Pedestrian-activated traffic signals

Table 7. Characteristics of sensory-impaired pedestrians (35, 43, 44, 45)

Characteristic	**Resulting in**	**Impacting on**
Reduction in hearing ability	Missing audible clues to traffic	• Need to reinforce visual information
Lack of contrast resolution	Reduced ability to distinguish objects	• Sign legibility
Reduced vision	Reduced ability to scan the environment	• Curb detection • Crossing locations • Hazard detection
Severe vision impairment	Use of mobility aid, guide dog and/or tactile feedback to navigate	• Tactile paving use

Table 8. Characteristics of wheeled pedestrians (35, 43, 44, 45)

Characteristic	Resulting in	Impacting on
More susceptible to effects of gravity	Slower speeds travelling uphill, faster speeds on level surfaces or downhill.	• Surface gradients. • Interaction with walking pedestrians.
Chair/scooter width effectively increases the width of the pedestrian	Greater width required to use a route or pass others.	• Crossing width. • Object placement.
Reduced agility	Increased turning radius.	• Places to turn around. • Horizontal alignment. • Surface quality.
Reduced stability	Greater potential for overbalancing.	• Sudden changes in gradient. • Maximum forwards and sideways reach to pedestrian-activated traffic signals.
User is seated	Eye level lower	• Location of pedestrian-activated traffic signals. • Position of signs.

3.3.4. Sight Distance at LRT Crossings

An important consideration at passive LRT crossings that are controlled only by signs is providing sufficient visibility for LRV operators to clearly see the entire grade crossing environment and for crossing users to clearly see approaching LRVs. Section of the MUTCD Part-8 requires for passive crossings controlled by STOP or YIELD signs that "the line of sight for an approaching light-rail transit operator is adequate from a sufficient distance such that the operator can sound an audible signal and bring the light-rail transit vehicle to a stop before arriving at the crossing" (28).

Adequate pedestrian sight distance is based on the time necessary for a pedestrian to see an approaching train, decide to cross the tracks, and completely cross the trackway before the train arrives. Figure 21 presents the pedestrian sight triangle for a double track crossing, where dp is the distance, the pedestrian must travel to safely cross the trackway before the LRV arrives, and dt is the distance the train travels in the amount of time it takes the pedestrian to cross distance dp. In Figure 21, a highway-rail grade crossing is displayed depicting a pedestrian walking across the tracks. An LRV is approaching from the left in the diagram. The distance the pedestrian travels from one side of the crossing to the other is 42 feet. This distance is broken up into the following respective components:

- 7 ft decision/reaction distance of 2 seconds at 3.5 ft/sec.
- 10 ft clearance area just before a rail track.
- 15 ft between two rail tracks.
- 10 ft from last rail track to clearance area.

Table 9 presents the typical minimal sight distances dt for various train speeds (29). The distances shown in the table are for a level, 90° crossing. If other circumstances are encountered, the values must be re-computed.

Furthermore, additional sight distance might be necessary at locations where elderly persons, who may walk more slowly, will likely use a crossing.

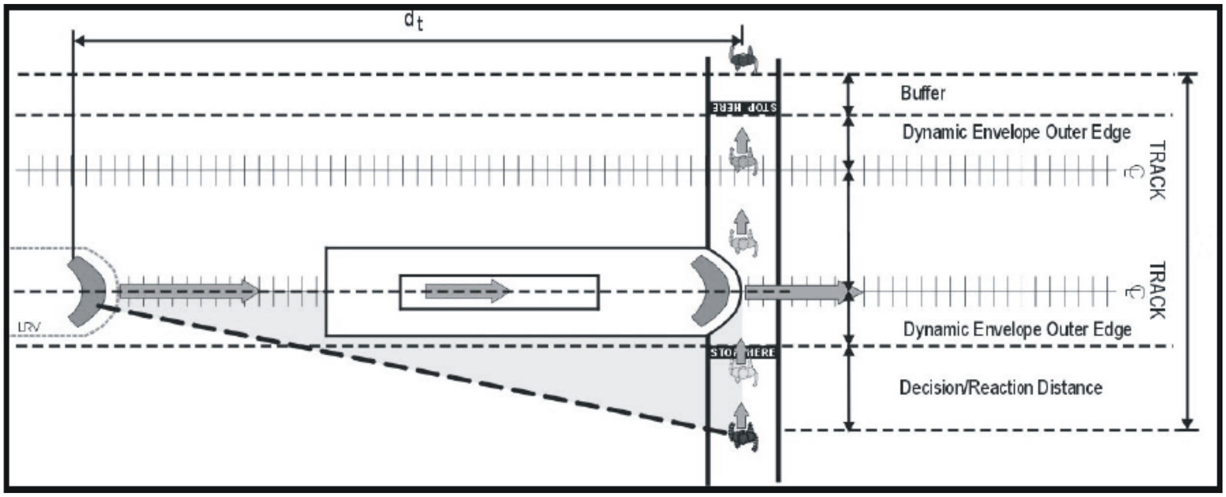


Figure 21. Pedestrian sight triangle

Table 9. Distance LRV travels during time it takes pedestrian to cross 42 feet

Train Speed (mph)	30	40	50	60	70	80	90
Distance dt (feet)	530	705	880	1,060	1,235	1,410	1,585

If a sight obstruction lies within the sight triangle, then an active positive control device must be installed. Sight distance obstructions at LRT crossings include sound walls, ticket vending machines, wayside communications housing, power substations, and occasionally the station access building itself. Fencing along the right-of-way may also limit sight distance if it is taller than 3.5 ft within 100–200 ft of the LRT crossing (measured along the LRT alignment back from the LRT crossing). This set-back distance depends on several factors, including speeds of approaching LRVs and the distance between the LRT tracks and the fencing (which depends on the right-of-way width). Therefore, the exact set-back distance between the LRT crossing and fence sections taller than 3.5 ft should be determined based on an engineering study of the LRT crossing in question. Likewise, landscaping near LRT crossings and stations may limit sight distance. Therefore, landscaping should be planned carefully so that it does not interfere with visibility. Further, landscaping should be maintained (e.g., routine pruning and trimming) so it does not become an obstruction in the future.

Although a crossing may be equipped with active warning devices, adequate sight distance is still a necessity for pedestrians. At crossings controlled by active devices, pedestrians may still enter the crossing if they do not see a train approaching. Also, if one train has already passed, pedestrians may enter the crossing unaware of a second train approaching from the opposite direction. The underlying factor is the necessity of adequate sight lines for the pedestrian.

4. METHODOLOGY

To achieve the objective of this project, the following tasks were undertaken:

1. Conduct literature review and survey of a sample of LRT agencies.
2. Synthesize best practices for reducing collisions between VRUs and LRVs.
3. Analyze safety data to determine the effects of alignment decisions, geometric design features, and risky pedestrian behavior on collision experience.
4. Identify the physical (engineering) treatments, public education programs, and law enforcement campaigns that can be applied in existing and new LRT systems to reduce collisions involving VRUs.
5. Develop a guidebook of best practices and a "PowerPoint Presentation" for use by LRT agencies, MPOs and state DOTs to improve the safety of VRUs in LRT systems and advance the professional capacity of future transit workforce.
6. Prepare final report documenting the findings of Tasks 1 through 5. The final report serves as guidebook of best practices.
7. Prepare PowerPoint Presentation" for educational, outreach and workforce development purposes.

The safety treatments described in this report were identified through an extensive review of the literature including national standards such as the MUTCD. In addition, phone, and online interviews of representatives of LRT agencies were conducted to survey their experience with implementing different safety treatments for improving safety of VRUs in their daily operations. Portland Tri-Met, Los Angeles County (LACMTA) Metro Blue Line, Houston Metro, Baltimore (MTA) Light Rail, Salt Lake City (UTA) Light Rail are notable examples of transit agencies included in the survey.

5. ANALYSIS AND FINDINGS

5.1. Analysis of Pedestrian-LRV Collision Data

Collisions between LRVs and pedestrians are relatively infrequent events and the number of collisions at a given location is often too small to be amenable to statistical analysis (1, 2). Between 2002 and 2007, the number of pedestrian collisions for each LRT agency averaged 1.3 collisions per year (24).

Given the infrequent and random nature of LRV-pedestrian collisions, most LRT safety studies examined the impacts of safety treatments along LRT alignments using simple before-and-after comparison of collisions, anecdotal evidence, crash surrogate measures such as violations, or some combination of the three approaches. The literature review did not find analysis of the impacts of safety treatments based on contemporary statistical techniques such as the empirical Bayes analysis (50, 51). The problem is compounded by the absence of comprehensive data elements on pedestrian-LRV collisions including accident investigation reports, collision diagrams, pedestrian volume, speed of LRV, rail and highway inventory data, and pedestrian distraction. Neither the NTD nor data collected by transit agencies provide sufficient detail for a statistical evaluation of the effectiveness of a particular treatment. NTD collision reports do not list the definitive cause of each collision and near misses are not reported.

Collision data available from the NTD for the years 2002 and 2003 along with detailed collision information from three LRT agencies (Los Angeles County Metropolitan Transportation Authority, Santa Clara Valley Transportation Authority, and San Diego Trolley, Inc.) were included in TCRP Research Results Digest 84 (7). The collision data were analyzed is to identify trends regarding the number, location, severity, and potential causes of pedestrian-LRV collisions.

5.1.1. Location of Collisions

Nearly one-half of pedestrian-LRV collisions occurred at grade crossings, but trespassing was a significant factor in a substantial number of collisions (7). As shown in Table 10, during 2002 and 2003, 27 of the 57 total injuries, or 47 percent, resulting from pedestrian-LRV collisions occurred at grade crossings. Only 8 of the collisions, or 14 percent, occurred at stations. For the NTD purposes, LRT stations are defined as revenue service facilities and may or may not include the grade crossings near the stations (these accidents are likely to be classified as occurring at grade crossings). The remaining 39 percent of collisions happened in “other” locations such as illegal mid-block crossings or on exclusive rights-of-way where pedestrian presence would likely constitute a trespassing violation. During 2002 and 2003, approximately 54 percent of fatal pedestrian-LRV collisions occurred at “other” locations whereas the highest percentage of non-fatal injuries happened at grade crossings.

Table 10. Fatal and non-fatal pedestrian-LRT injuries by (2002-2003)

Location	Fatal	Non-Fatal	Total
Grade Crossings	5	22	27
Stations	1	7	8
Other	7	15	22
Total Injuries	13	44	57

Note: Crossings include grade crossings & intersections. The incidents at stations include all the accidents in the NTD that occurred at revenue facilities.

5.1.2. Crossing Controls

Most of the at-grade crossings where collisions occurred had active crossing control devices. As shown in Table 11, a total of 27 pedestrian injuries were reported at grade crossings in 2002 and 2003; 17 of these were listed at crossings with active control and 2 had passive control. The controls for the remaining 8 injuries were not listed, although it is likely that most of these injuries happened at locations with active control because most grade crossings have some type of active control (7).

Table 11. Total pedestrian-LRT injuries by control type and crossing (2002-2003)

Control Type	Crossings	Stations	Other	Total
Active	17	3	4	24
Passive	2	0	0	2
Other	0	0	0	0
Not Listed	8	5	12	25
None	0	0	6	6
Total	27	8	22	57

Table 12 presents a breakdown of all the injuries (fatal and non-fatal) that occurred at locations with active crossing control devices in 2002 and 2003. The major categories of active crossing control devices include crossing gates, traffic signals, flashers/lights/bells, and other. Most injury accidents occurred at locations controlled by gates and traffic signals. Locations controlled by traffic signals accounted for approximately 46% of all injury accidents and locations controlled by gates accounted for 38% of all injury accidents.

Table 12. Total pedestrian-LRT injuries at different locations by type of active crossing control devices (2002-2003)

Control Type	Crossings	Stations	Other	Total
Gates	7	2	0	9
Traffic Signals	9	0	2	11
Flashers/Lights/Bells	1	1	0	2
Other	0	0	2	2
Total	17	3	4	24

5.1.3. Crash Prediction Models

Linear regression analysis was performed to examine the relationship between the number of pedestrian-LRV collisions and five possible predictive variables:

- Annual revenue service miles,
- Directional route miles,
- At-grade track miles,
- Number of grade crossings,
- Number of stations.

Table 13 presents summary of the regression statistics for each variable. The variables are organized by the degree of statistical significance in explaining the variability in the number of collisions. Generally speaking, t-statistics greater than 2 are considered statistically significant with a 95% level of confidence. Results of the statistical analysis showed a fairly strong correlation between the number of pedestrian-LRV collisions and both annual revenue service miles and directional route miles. These two variables have the highest R-squared values, f-statistics, and t-statistics.

The results also indicate poor correlations between the number of pedestrian- LRV collisions and both at-grade track miles and the number of grade crossings per track mile. No correlation was found with the number of stations.

Figure 22 shows the linear regression of annual revenue service miles, which has the strongest relationship with pedestrian-LRT crashes. Despite the general correlation between revenue service miles and collisions, there is substantial variability in collision rates (collisions per revenue service mile) among transit agencies. Nine of the LRT operating agencies in the U.S. did not report any pedestrian-LRV collisions during the two-year period between 2002 and 2003. The remaining agencies with more than 40,000 annual revenue service miles have rates ranging from a low of 0.22 collisions per million miles to a high of 2.25 collisions per million miles. Thus, the highest pedestrian-LRV collision rate is more than 10 times higher than the lowest rate.

It should be noted that the usefulness of the statistical analysis is somewhat limited because of limited available data. Changes in NTD reporting requirements makes it difficult to obtain large sample size.

Table 13. Summary of regression analysis results

Predictive Variable	R-Squared	f-Value	Significance	t-Value
Annual revenue service miles	0.37	11.74	0.003	3.4
Directional route miles	0.32	9.51	0.006	3.1
At-grade track miles	0.17	4.11	0.056	2.0
Number of grade crossings	0.14	3.24	0.087	1.8
Number of stations	0.07	1.55	0.228	1.2

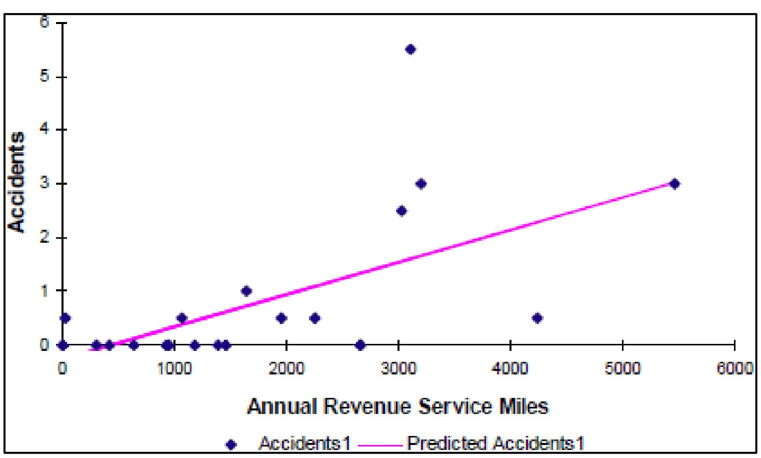


Figure 22. Linear regression of pedestrian-LRT collisions and annual revenue service miles (7)

5.2. Key Findings of Transit Agency Collision Data Analysis

Following is a summary of the key findings of the analysis of collision data obtained from the three LRT agencies (Los Angeles County Metropolitan Transportation Authority, the Santa Clara Valley Transportation Authority, and San Diego Trolley, Inc.) (7):

- The number of pedestrian-LRT collisions per year is relatively small. It may be concluded that existing grade crossing measures and LRT operating procedures are effective at preventing pedestrian-LRT collisions.
- Pedestrian-LRT collisions are more likely to result in fatalities than vehicle-LRT collisions. This is not an unusual result considering the lack of physical protection for pedestrians.
- Most pedestrian-LRT collisions occur at grade crossings.
- Most collisions occur at locations with active crossing control devices.
- The higher number of collisions at traffic signal-controlled crossings versus gated crossings suggests that lack of visual, physical, and/or audible measures decreases pedestrian safety.
- Audible devices may not protect against many causes of pedestrian- LRT collisions, particularly those attributed to intoxication and trespassing. Furthermore, distraction from cell phones and headsets are difficult to overcome using audible devices.
- Many collisions involving VRUs occur at locations with physical (gates), audible (bells and horns), and visual warnings (flashers and lights). These accidents are likely due to risky pedestrian behavior that is independent of the degree of crossing protection.
- There are situations where audible warnings are ignored because of factors other than risky behavior such as:
    - Second train coming. This type of collision occurs when a pedestrian enters a crossing against the active crossing control devices after a train clears the crossing and the pedestrian is unaware of a train approaching from the opposite direction.
    - Active joint use corridors. In situations where both slower moving and louder freight trains share crossing control devices with faster and quieter LRT systems, some pedestrians enter a crossing against the active protection devices thinking that they are warning the approach of a freight train rather than the LRV.
- There is substantial variability in collision rates among transit agencies. Some of this variability is explained by the size of the LRT system (e.g., annual revenue service miles); however, much of it is not explained.
- Site- or alignment-specific factors that are unique to transit agencies may be significant contributors to pedestrian-LRT accidents.
- The variation in collision rates and trends indicates that national statistics have limited usefulness when evaluating the safety performance of individual LRT agencies.

5.3. VRU Safety Treatments

VRU safety treatments in LRT environments may be grouped into three major categories: 1) physical treatments (sometimes referred to as engineering treatments) in the immediate environment surrounding the LRT tracks, 2) public education and awareness programs for passengers and people who live, work, or go to school near the LRT alignment, and 3) enforcement campaigns. Table 14 presents a listing of these treatments. Some of these treatments are widely used while others are less commonly employed.

Safety treatments can be applied system-wide or to specific locations (e.g., grade crossings). Individual treatments are often applied as part of an integrated safety improvement package, as some safety issues cannot be addressed by a single treatment alone. However, when a package of treatments is applied, it may be difficult to determine the effect on safety of the individual treatments included in a package.

5.3.1. Physical Treatments

Physical treatments can be passive or active. Passive treatments are static and do not change with the approach of the LRV, whereas active treatments react when an LRV approaches the location. Examples of passive physical treatments include signs that warn pedestrians about grade crossings and pavement markings that delineate the LRV dynamic envelope. Examples of active physical treatments include LRV-activated "Train-Coming" icons, pedestrian auditory icons, and automatic pedestrian gates. Taken as a whole, active treatments are more effective than passive treatments -- the change that occurs in an active device has the effect of generating attention from the intended audience of pedestrians and cyclists. This can increase the effectiveness of the basic message.

Active treatments that are not well designed, maintained, and tuned to their environment lose their intended impact. For example, flashing lights and bells operating longer than necessary at a pedestrian crossing are ignored by pedestrians. As a result, pedestrians and cyclists in the vicinity cross the tracks regardless of the warning. Although the warning message is clear, the reliability of the information is treated as incorrect by pedestrians. Another example is when an active "second train coming" warning sign has poor contrast and is essentially unreadable in daylight conditions, so the message is not effectively delivered.

Table 15 presents summary of notable physical treatments for improving safety of VRUs in LRT environments. These treatments address the five most critical areas of safety concerns that face LRT agencies: 1) inattention of pedestrians approaching the LRT alignment, 2) confusion of those approaching the LRT alignment, 3) lack of appropriate separation between pedestrians and the LRV, 4) risky behavior by those approaching the LRT alignment, and 5) LRV operator error or lack of information.

The physical treatments discussed in this section were identified through an extensive review of the research literature including national standards such as the MUTCD. In addition, LRT agencies were contacted regarding the implementation of successful solutions to pedestrian safety issues which they face in their daily operations. Since no two LRT systems are identically similar, and because of the large number of variables to be considered (type of alignment, LRV speed, geometry of grade crossing, etc.), no single standard set of treatments is universally applicable to all LRT environments. Deciding on the set of physical treatments that will provide the greatest safety benefits for pedestrians and cyclists in a given LRT environment requires transit and highway agency staff, engineers, and community leaders to engage in problem-solving. The problem-solving effort will often require application of engineering judgment, as well as judgments based upon understanding of pedestrian behavior and the local conditions.

Table 14. Common pedestrian-LRT safety treatments

Objective	Treatments
Improve pedestrian awareness of LRT grade crossings	Passive pedestrian signs. “Stop Here” pavement marking.
Reduce pedestrian risky behavior at LRT grade crossing and stations	Manual swing gates. Z-crossings. Channelization using fencing, barriers, or landscaping. Pedestrian signals. LRT safety education and awareness programs. Law enforcement campaigns.
Improve pedestrian awareness of an approaching LRV	Active visual warnings. “Train-Coming” icon. Pedestrian auditory icons, directional verbal warnings. and audible devices. Pedestrian automatic gates. Automatic swing gates. “Second Train Coming” signs. Directional LRT pavement markings between tracks.
Improve sight distance at grade crossings	Provide clear sight triangles. Redesign pedestrian path across trackway. Eliminate screening by physical objects.
Reduce pedestrian exposure to vehicular traffic	Provide pedestrian refuge areas. Provide sufficient queuing areas and wide platforms. Install sidewalk if it does not exist.
Reduce pedestrian jaywalking and trespassing at midblock locations	Provide sidewalk if it does not exist. Install fences/barriers between tracks. Install fences/barriers to separate LRT right-of-way. Provide curbside landscaping and bollards.
Reduce information overload	Remove unwarranted traffic control devices
Improve pedestrian safety awareness and behavior	Provide public education and awareness programs. Conduct law enforcement campaigns. Mount signs at average eye height of pedestrians.
Meet the needs of persons with disabilities	Tactile warning strip. Delineate safe pedestrian path by color and texture. Pedestrian audible devices. Provide “easy-access” stop for center-running LRV operations in mixed traffic.
Reduce Operating rule violations	Staff training.

Table 15. Summary of physical treatments

Category	Description	Passive	Active
Signs	1. Grade crossing (Crossbuck) sign 2. Number of tracks sign 3. Look both ways sign	x x x	
Signals & active warnings	1. Audible crossing warning devices 2. Flashing light signals 3. Limits on downtime of gates 4. Illuminated, active, in-pavement marking systems 5. LRV-activated blank-out signs 6. Grade crossing status indicator signals 7. Pedestrian signals		x x x x x x x
Second train approaching treatments	1. Second train approaching signals & active signs 2. Second train warning signs	 x	x
Pedestrian gates	1. Pedestrian automatic gates 2. Pedestrian manual swing gates	 x	x
Channelization	1. Pedestrian fencing & landscaping 2. Offset pedestrian crossings (Z-crossings) 3. Quick curbs 4. Pedestrian refuge areas	x x x x	
Markings	1. Dynamic envelope markings 2. Pavement word and symbol markings 3. Tactile warning strips	x x x	
Illumination	1. Illumination of grade crossings	x	
Intrusion & obstacle detection systems	1. Video surveillance and intrusion detection 2. Wireless sensor networks		x x
Reducing visual clutter & information overload	1. Conservative use of signs and waning devices	x	

The treatments presented in Table 15 are grouped into nine general categories:

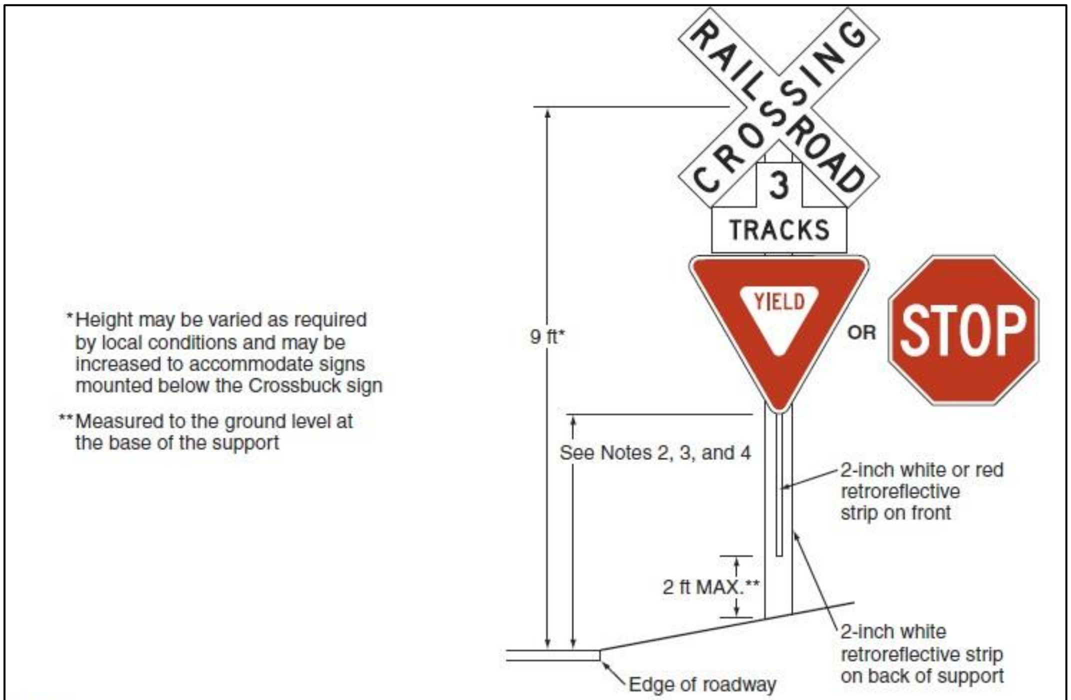
1. Signs
2. Signals and active warnings
3. Second train approaching treatments
4. Pedestrian gates
5. Channelization
6. Markings
7. Illumination
8. Intrusion and obstacle detection systems
9. Reducing visual clutter and information overload.

The above categories are intended for presentation purposes only, and some treatments may fall into more than one category, but each treatment has been listed only once. The following sections provide detailed description of the available physical treatments for improving pedestrian safety.

5.3.1.1. Passive Signs

Passive signs do not change in response to an approaching LRV. They regulate, warn, and guide road users and LRV operators in mixed-use alignments. At grade crossings, they are used to identify and direct attention to the location of crossing and advise road users to slow down and stop when rail traffic is occupying or approaching the grade crossing.

According to Section 8B.03 of the MUTCD, the Grade Crossing sign (known as the Crossbuck sign) may be used on a highway approach to a highway-LRT grade crossing on a semi-exclusive or mixed-use alignment, alone or in combination with other traffic control devices. In most states, the Crossbuck sign requires road users to yield the right-of-way to rail traffic at a grade crossing. The Crossbuck sign is shown in Figure 23. If automatic gates are not present and if there are two or more tracks at a grade crossing, the number of tracks shall be indicated on a supplemental Number of Tracks (R15-2P) plaque of inverted T shape mounted below the Crossbuck sign.



Notes:

1. YIELD or STOP signs are used only at passive crossings. A STOP sign is used only if an engineering study determines that it is appropriate for that particular approach.
2. Mounting height shall be at least 4 feet for installations of YIELD or STOP signs on existing Crossbuck sign supports.
3. Mounting height shall be at least 7 feet for new installations in areas with pedestrian movements or parking.

Figure 23. Grade crossing (R15-1) sign and number of tracks plaque (R15-2P), (MUTCD figure 8B-2)

The LOOK (R15-8) sign shown in Figure 24 may be used at grade crossings to inform pedestrians of the increased risk as they approach an LRT grade crossing. The LOOK sign may be mounted as a supplemental plaque on the Crossbuck support, or on a separate post in the immediate vicinity of the grade crossing on the LRT right-of-way.

The mounting height of pedestrian-only signs should be less than 6.5 ft above pavement (2). These signs should be installed so that pedestrians walking on an intended path will not run into them. Several LRT agencies have installed LOOK signs at a height of 4 ft between the two directional tracks at pedestrian grade crossings and station locations. The signs are installed within the cone of vision where pedestrians tend to look while they are walking. Figure 25 shows example of low-mount installation.

5.3.1.2. Signals and Active Warnings

Signals and active waning devices inform road users of the presence of LRV traffic at grade crossings and stations. These treatments include railroad-type flashing-light signals, audible warning devices, highway pedestrian signals, automatic pedestrian gates, actuated blank-out and variable message signs, illuminated in-pavement marker systems, grade crossing status indicator signals, and other active traffic control devices. They are activated by the passage of a train over a detection circuit in the track except in those few situations where manual control or manual operation is used. Active control devices are usually supplemented with passive signs and pavement markings.

Figure 24. "LOOK" pedestrian sign, Tri-Met, Portland, OR

Figure 25. "Watch for Trains" pedestrian sign, DART, Dallas, TX

Audible Crossing Warning Devices. Audible warning devices such as bells, horns, and audible messages are among the means used in LRT environments to alert pedestrians, cyclists, and vehicles to oncoming trains at grade crossings and stations. The key design issues to consider are appropriate placement of the device, and tuning the sound produced so that the warning sound can easily be distinguished from the environmental noise in the area. Improving placement and the type of tone are believed to be more effective than simply increasing the device volume (7).

Depending on their location, audible warning devices can be divided into two groupings: on-board the LRV, and wayside along the tracks. TCRP research results Digest 84 (7) presents guidance on practices that should be considered when designing or developing operating procedures for audible warning devices. Operating procedures on use of on-board horns are usually included in the LRT agency's rulebook. Figure 26 shows an on-board LRV-mounted audible warning device.

Figure 26. On-board LRV-mounted audible warning device, Santa Clara, CA

Pedestrian-Only Grade Crossings. Pedestrian-only grade crossings can be passive, active with railroad-type control, or active with traffic signal control. Passive pedestrian-only crossings include a passive warning sign (e.g., STOP sign or Crossbuck sign). Supplemental passive treatments may incorporate channelization and pavement marking techniques, including Z-crossings and swing gates. Audible warnings of an LRV arrival are only produced by a train-mounted device.

Pedestrian-only crossings with railroad-type flashing light devices always include an audible device, typically consisting of a crossing bell. In addition to flashing lights and bells, active pedestrian-only crossings sometimes have gates that pedestrians must pull open to cross the tracks.

Figure 27 illustrates the standard warning device at pedestrian-only crossings included in Part-8 of the MUTCD. The mechanical or electronic bell of the standard pedestrian crossing device is about 15 feet above the ground. This mounting height results in the audible warning being broadcast to a relatively wide area. In addition, the flashing lights and all signage are mounted more than 7 feet high so that pedestrians do not bump their heads on them since most pedestrians tend to look down not up while walking. Figure 28 shows a low-mount waning device installed in Portland's Tri- Met system. This alternative treatment addresses the issues of height compatibility with pedestrians' field of view and noise spillover into the surrounding community.

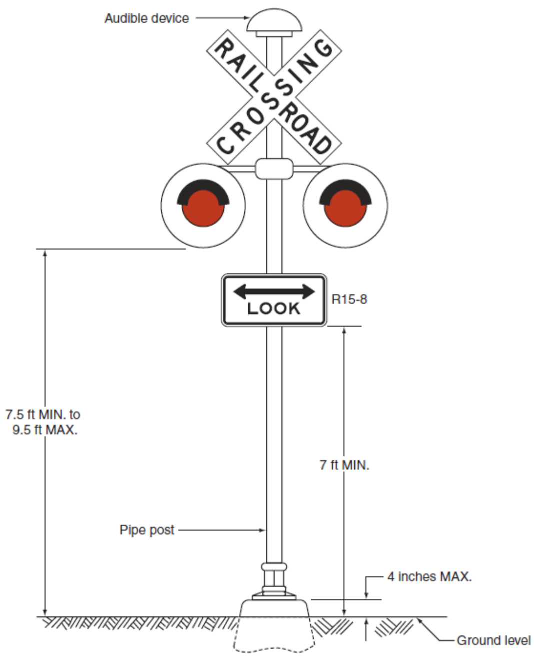


Figure 27. LRT flashing-light signal assembly for pedestrian crossings (MUTCD Figure 8C-4)

Figure 28. Low-mount flashing light signal, Tri-Met, Portland, OR

Audible devices are not always provided at pedestrian-only crossings with traffic signal controls (21). Other treatments may consist solely of a verbal warning (e.g., some systems have audible announcements on the station platforms, such as "train approaching, stand back"). Figure 29 illustrates a pedestrian signal on the Hiawatha line, Minneapolis that incorporates an audible crossing warning device and "LOOK BOTH WAYS" sign.

Figure 29. Pedestrian signal with audible crossing warning device and "LOOK BOTH WAYS" sign, Hiawatha line, Minneapolis, MN

Railroad-Type Flashing Light Signals. Section 8C.03 of the MUTCD Part-8 states that "Highway-LRT grade crossings in semi-exclusive alignments shall be equipped with flashing-light signals where LRT speeds exceed 35 mph. Flashing-light signals shall be clearly visible to motorists, pedestrians, and bicyclists. If flashing-light signals are in operation at a highway-LRT crossing that is used by pedestrians, bicyclists, and/or other non-motorized road users, an audible device such as a bell shall also be provided and shall be operated in conjunction with the flashing-light signals."

In addition, Section 8C.13 of the MUTCD Part-8 states that "Flashing-light signals with a Crossbuck (R15-1) sign and an audible device should be installed at pedestrian and bicycle crossings where an engineering study has determined that the sight distance is not sufficient for pedestrians to complete their crossing prior to the arrival of the LRT traffic at the crossing, or where LRT speeds exceed 35 mph."

Several types of flashing light signals are used by transit agencies to warn motorists, pedestrians, and bicyclists at LRV crossing area. The most common type is the standard railroad-type crossing lights shown in Figure 30.

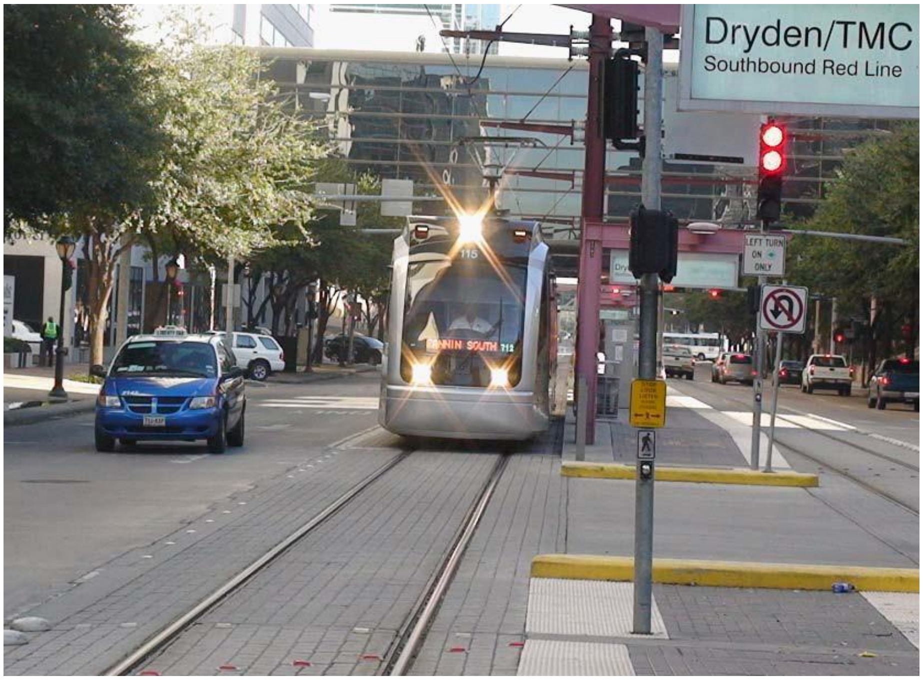
Figure 30. Standard railroad crossing flashing-light signals with gate arm, Gold Line LRT, Pasadena, CA

Illuminated, In-Pavement Marker Systems. Illuminated in-pavement marker (IPM) systems consist of a series of markers that are embedded in the pavement surface and light up when activated by an approaching train. They can be installed parallel to the LRT alignment or at a stop bar at LRT grade crossings. The flashing rate and color of the markers provide motorists, pedestrians, and bicyclists with an enhanced warning that has generally been shown to increase driver and pedestrian awareness of an approaching LRV. Illuminated IPM can be used in combination with other active treatments such as blank-out signs.

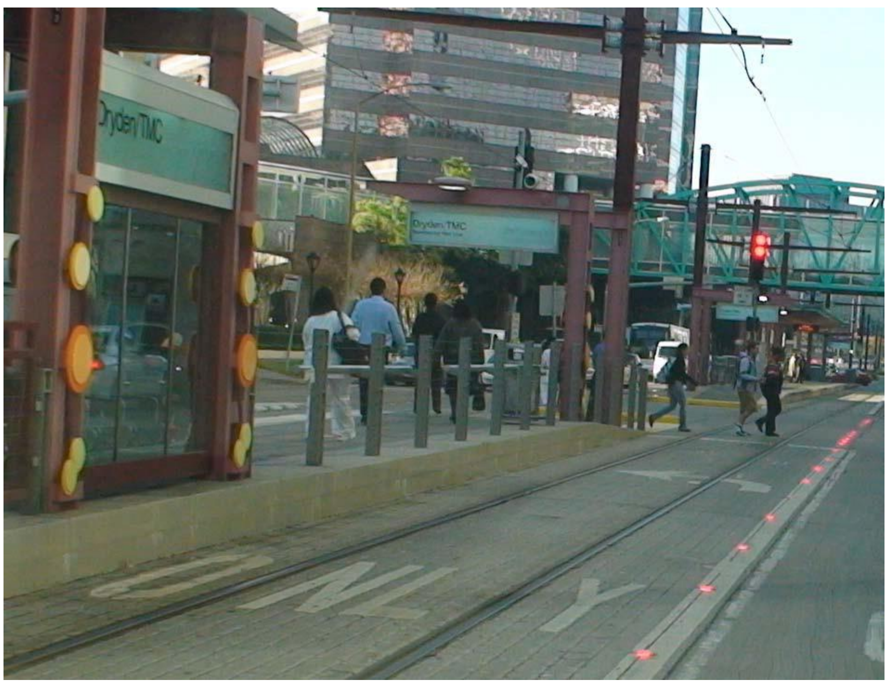
Typically, IPM units consist of an illumination source surrounded by a protective housing and lens, a power source, and a system controller in a protective enclosure. Both incandescent/halogen lamps and light-emitting diodes (LED) have been used as light sources in IPM systems. Laser and electroluminescence technologies have also been considered for use; however, each has respective limitations preventing widespread applications. Flexibility in color and luminous intensity, low power consumption, and extended useful life, have caused LED to emerge as the favored light source for IPM systems.

IPM systems can be powered through standard hardwired electrical connections, inductive wireless connections, or through solar technology. Hardwired electrical connections and inductive wireless connections produce higher luminous intensity and more consistent operation than individual solar-powered IPM units. Benefits to solar-powered IPM systems, however, include the ease and flexibility of installation, particularly for remote areas (52). Continued advancements in solar technology may make this a more viable IPM system power source in the future.

Markers can be recessed in the pavement through coring or milling methods or affixed directly to the pavement surface. Recessed markers are less prone to "pop-offs" but require additional work during the installation process. In cold regions, where snowplowing is frequent during the winter months, use of recessed markers is necessary. Also, the performance of marker adhesives, particularly in unusually cold or hot temperatures, can have a significant effect on pop-off frequency. Figure 31 illustrates the illuminated IPM systems installed in Houston Metro.



(a) IPM system – Status: Not active



(b) IPM system – Status: active

Figure 31. Illuminated IPM system, Houston Metro, TX

LRV-Activated Blank-Out Signs. LRV-activated blank-out signs are used to warn motorists and pedestrians of an LRV approaching the crossing location. When activated, blank-out signs are illuminated to display a message to roadway users, e.g., the presence of a train or a second train approaching. LRV-activated blank-out warning signs may be used at signalized intersections near highway-LRT grade crossings or at crossings controlled by STOP signs or automatic gates. Figure 32 shows example of LRV-activated sign installed at a signalized intersection in Houston, TX.

(a) Blank-out sign – Status: not active

(b) Blank-out sign – Status: active

Figure 32. LRV-activated blank-out sign, Houston Metro, TX

LRT agencies reported that blank-out signs are more effective than static signs, particularly when blank-out signs provided more specific, useful, and timely information to motorists, pedestrians, and cyclists (10). Blank-out signs should be illuminated long enough to allow motorists and pedestrians to respond and clear the tracks, but not so long that the sign becomes ineffective (perceived as incorrect) or easy to ignore.

Pedestrian Signals. Pedestrian signals are active devices that inform pedestrians when it is safe to cross the roadway or right-of-way. According to Chapter 8C of the MUTCD, pedestrian signals for LRT crossings should be designed in accordance with the standards and guidance included in Chapter 4E of the MUTCD (28).

Chapter 8C also recommends that: "where light-rail transit tracks are immediately adjacent to other tracks or a road, pedestrian signalization should be designed to avoid having pedestrians wait between sets of tracks or between the tracks and a road. If adequate space exists for a pedestrian refuge and is justified based on engineering judgment, additional pedestrian signal indicators, signing, and detectors should be installed."

As shown in Figure 33, pedestrian signal heads provide special types of traffic signal indications exclusively intended for controlling pedestrian traffic. These signal indications consist of the illuminated symbols of a WALKING PERSON (symbolizing WALK) and an UPRAISED HAND (symbolizing DON'T WALK). According to the MUTCD, all new pedestrian signal head indications shall be displayed within a rectangular background and shall consist of symbolized messages, except that existing pedestrian signal head indications with lettered or outline style symbol messages shall be permitted to be retained for the remainder of their useful service life. Countdown signals may also be incorporated. The countdown signals may be activated by train detection systems or GPS (10).

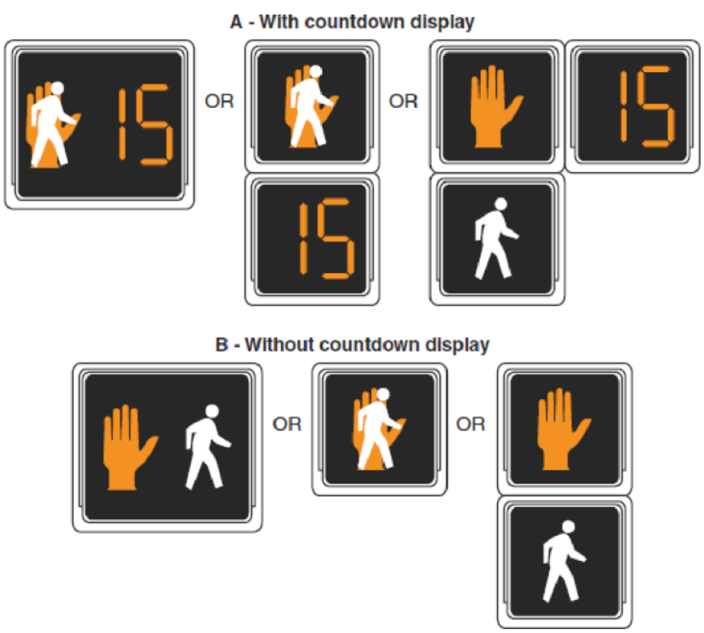


Figure 33. Typical pedestrian signal indications (MUTCD figure 4E-1)

The MUTCD requires that pedestrian signal heads be mounted with the bottom of the signal housing including brackets not less than 7 feet or more than 10 feet above sidewalk level and shall be positioned and adjusted to provide maximum visibility at the beginning of the controlled crosswalk. At narrow crossings, these mounting heights may be too high for the short distance across just one or two tracks. A lower placement more central to a pedestrian's field of vision may be better, but the signal head location needs to be carefully selected to avoid the signal head becoming a pedestrian hazard in itself (10). Figures 34 through 36 show variations of pedestrian signals installed at different LRT systems.

Figure 34. Pedestrian signal with "LOOK" sign and flashing lights, Metro Transit's Hiawatha line, Minneapolis, MN

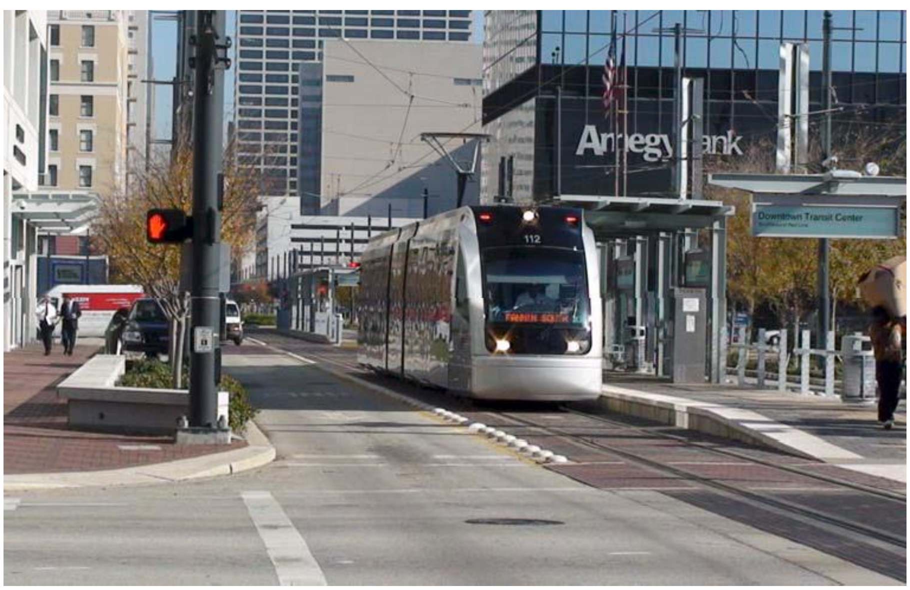


Figure 35. Pedestrian signal with pushbuttons, Houston Metro, Houston, TX

Figure 36. Pedestrian signals, DART, Dallas, TX

Pedestrian Intervals. Pedestrians should be provided with sufficient time to cross the roadway or right-of-way every signal cycle unless pedestrian detectors are installed. Figure 37 illustrates the pedestrian intervals and their possible relationships with associated vehicular signal phase intervals.

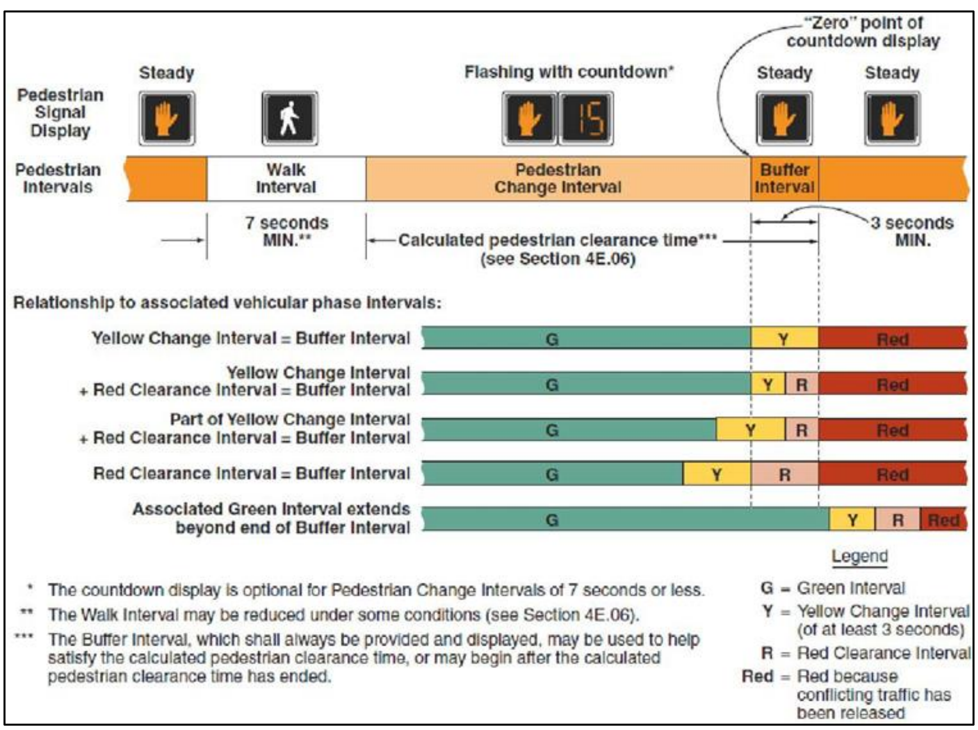


Figure 37. Pedestrian intervals (MUTCD figure 4E-2)

The walk interval, during which the WALKING PERSON is displayed, should be at least 7 seconds in length so that pedestrians will have adequate opportunity to react and leave the curb or shoulder before the pedestrian clearance time begins. However, if pedestrian volumes and characteristics do not require a 7-second walk interval, walk intervals as short as 4 seconds may be used.

A pedestrian change interval consisting of a flashing UPRAISED HAND (symbolizing DON'T WALK) signal indication shall begin immediately following the WALKING PERSON (symbolizing WALK) signal indication. Following the pedestrian change interval, a buffer interval consisting of a steady UPRAISED HAND (symbolizing DON'T WALK) signal indication shall be displayed for at least 3 seconds prior to the release of any conflicting vehicular movement. The sum of the time of the pedestrian change interval and the buffer interval shall not be less than the calculated pedestrian clearance time. The buffer interval shall not begin later than the beginning of the red clearance interval, if used.

The pedestrian clearance time should be sufficient to allow a pedestrian who left the curb or shoulder at the end of the WALKING PERSON signal indication to travel at a walking speed of 3.5 feet per second to at least the far side of the traveled way or to a median of sufficient width for pedestrians to wait. The additional time provided by an extended pushbutton press to satisfy pedestrian clearance time needs may be added to either the walk interval or the pedestrian change interval.

As shown in Figure 37, during the yellow change interval, the UPRAISED HAND (symbolizing DON'T WALK) signal indication may be displayed as either a flashing indication, a steady indication, or a flashing indication for an initial portion of the yellow change interval and a steady indication for the remainder of the interval.

According to Chapter 4E of the MUTCD, the total of the walk interval and pedestrian clearance time should be sufficient to allow a pedestrian crossing in the crosswalk who left the pedestrian detector (or, if no pedestrian detector is present, a location 6 feet from the face of the curb or from the edge of the pavement) at the beginning of the WALKING PERSON (symbolizing WALK) signal indication to travel at a walking speed of 3 feet per second to the far side of the traveled way being crossed or to the median if a two-stage pedestrian crossing sequence is used. Any additional time that is required to satisfy these conditions should be added to the walk interval.

Countdown Pedestrian Signals. Pedestrian countdown signal heads are beneficial at intersections with high pedestrian crossing volumes and/or long crossing distances. Countdown signal heads indicate the number of seconds remaining for pedestrians to complete crossing the street before opposing traffic is allowed to proceed.

Section 4E.07 of the MUTCD requires pedestrian signal heads used at crosswalks where the pedestrian change interval is more than 7 seconds to include a pedestrian change interval countdown display in order to inform pedestrians of the number of seconds remaining in the pedestrian change interval. Where countdown pedestrian signals are used, the countdown shall always be displayed simultaneously with the flashing UPRAISED HAND (symbolizing DON'T WALK) signal indication displayed for that crosswalk.

Countdown pedestrian signals shall consist of Portland orange numbers that are at least 6 inches in height on a black opaque background. For crosswalks where the pedestrian enters the crosswalk more than 100 feet from the countdown pedestrian signal display, the numbers should be at least

9 inches in height. As depicted in Figure 33, the countdown pedestrian signal shall be located immediately adjacent to the associated UPRAISED HAND (symbolizing DON’T WALK) pedestrian signal head indication.

The display of the number of remaining seconds shall begin only at the beginning of the pedestrian change interval (flashing UPRAISED HAND). After the countdown displays zero, the display shall remain dark until the beginning of the next countdown. Countdown displays shall not be used during the walk interval or during the red clearance interval of a concurrent vehicular phase.

Pedestrian Detectors. Pedestrian detectors may be pushbuttons or passive detection devices. Passive detection devices register the presence of a pedestrian in a position indicative of a desire to cross, without requiring the pedestrian to push a button. Some passive detection devices are capable of tracking the progress of a pedestrian as the pedestrian crosses the roadway for the purpose of extending or shortening the duration of certain pedestrian timing intervals.

If pedestrian pushbuttons are used, they should be capable of easy activation and conveniently located near each end of the crosswalks. According to the MUTCD, pedestrian pushbuttons should be located to meet all of the following criteria (28):

- Unobstructed and adjacent to a level all-weather surface to provide access from a wheelchair.
- Where there is an all-weather surface, a wheelchair accessible route from the pushbutton to the ramp.
- Between the edge of the crosswalk line (extended) farthest from the center of the intersection and the side of a curb ramp (if present), but not greater than 5 feet from said crosswalk line.
- Between 1.5 and 6 feet from the edge of the curb, shoulder, or pavement.
- With the face of the pushbutton parallel to the crosswalk to be used; and
- At a mounting height of approximately 3.5 feet, but no more than 4 feet, above the sidewalk.

Section 2B.52 of the MUTCD requires that signs be mounted adjacent to or integral with pedestrian pushbuttons, explaining their purpose and use. Figure 38 shows photograph of a pedestrian sign integrated with pushbutton.

Figure 38. Pedestrian sign integrated with pedestrian pushbutton

Accessible pedestrian signals (APS) and detectors provide information in non-visual formats (such as audible tones, speech messages, and/or vibrating surfaces) to meet the needs of pedestrians who are blind or visually impaired to cross the roadway. They are typically integrated into the pedestrian detector (pushbutton), so the audible tones and/or messages come from the pushbutton housing. They have a pushbutton locator tone and tactile arrow and can include audible beaconing and other special features.

According to Section 4E.09 of the MUTCD, accessible pedestrian signals shall have both audible and vibrotactile walk indications. Vibrotactile walk indications are provided by a tactile arrow on the pushbutton that vibrates during the walk interval. The vibrotactile indications provide information to pedestrians who are blind and deaf and are also used by pedestrians who are blind or who have poor vision to confirm the walk signal in noisy environments.

At accessible pedestrian signal locations where pedestrian pushbuttons are used, each pushbutton shall activate both the walk interval and the accessible pedestrian signals.

Second Train Approaching Treatments. One of the leading causes of pedestrian-LRV collisions on double track LRT grade crossings is pedestrians being unaware of a second train approaching from behind a train immediately in front of them. This situation is very confusing and potentially dangerous to pedestrians and cyclists. Too often, pedestrians walk over the tracks as soon as the train in front of them passes, and then are struck by the second train approaching from the opposite direction.

Signals and active "Second Train Coming" signs have been used by LRT agencies to warn pedestrians, motorists, and cyclists of a second train approaching. Although the sign messages and technology used differ among LRT systems, the underlying principle is the same. A second train activates the signal and the active sign through special track circuitry to warn pedestrians and motorists of its approach.

Second train approaching signals and active signs must be designed and placed where they can be clearly seen. The signals are more effective when the warning is within a short time of the second train approaching. Signs that are on for too long may be ignored. The effectiveness of the signs is increased if they deliver specific and valuable information to motorists, pedestrians, and cyclists, e.g., the direction from which the second train is approaching.

The active "Second Train Coming" sign shown in Figure 39 is installed at the Vernon Avenue grade crossing adjacent to an LRT station in Los Angeles, CA. When activated, the sign is illuminated to indicate that a second train is approaching the crossing. The sign is capable of providing information on the direction of the second approaching train.

5.3.1.3. Pedestrian Gates

Pedestrian gates are positive barriers that force pedestrians and cyclists to stop or pause at the entrance to an LRT grade crossing. They include automatic gates and manual swing gates.

Automatic Gates. Pedestrian automatic gates are arms that physically block the pedestrian or cyclist path across the LRT tracks when the gates are activated by an approaching train. According to Section 8C.05 of the MUTCD, highway-LRT grade crossings in semi-exclusive alignments should be equipped with automatic gates and flashing-light signals where LRT speeds exceed 35 mph. Section 8C.05 also states that "Traffic control signals may be used instead of automatic gates at highway-LRT grade crossings within highway-highway intersections where LRT speeds do not

(a) Southbound LRV

(b) Northbound LRV

Figure 39. Active second train warning sign at Vernon Avenue, LA LRT Metro Blue, Los Angeles, CA

exceed 35 mph. Traffic control signals or flashing-light signals without automatic gates may be used where the crossing is at a location other than an intersection and where LRT speeds do not exceed 25 mph and the roadway is a low-volume street where prevailing speeds do not exceed 25 mph."

In general, pedestrian automatic gates should be installed at all pedestrian crossings with limited sight distance (see section 3.3.4). When sight distance is limited, pedestrians cannot see an approaching LRV until it is very close to the crossing. Likewise, LRV operators cannot see pedestrians in the vicinity of the crossing until the LRV is very close. When this condition exists, pedestrian automatic gates are essential. For example, if a pedestrian crossing is controlled only by flashing light signals and bells, a pedestrian might enter the crossing despite activated warning devices, thinking that an LRV is not approaching the crossing because there is no visual contact. The LRV may actually be approaching the crossing but, because of obstructions, the pedestrian is unable to see the LRV and the LRV operator is unable to see the pedestrian.

Figure 40 shows a shared pedestrian/roadway automatic gate. In this case, the pedestrian gate is part of the vehicle gate, with both pedestrians and vehicles blocked by a single gate that is placed behind the sidewalk. A second gate is required on the downstream side of the rail crossing for pedestrians approaching the crossing from the opposite direction.

As an alternative, Figure 41 illustrates a pedestrian automatic gate separate from the automatic gate for vehicles. The pedestrian gate may have a separate assembly, or it may share the same assembly with the vehicle automatic gate. In the case of shared assembly, a separate drive mechanism should be provided for the pedestrian automatic gate so that a failure in the pedestrian automatic gate unit will not affect vehicle automatic gate operations. To provide four-quadrant warning, a single-unit pedestrian automatic gate should also be installed on the curbside of the sidewalk, across the tracks, opposite the vehicle automatic gate/pedestrian automatic gate joint assembly. A skirt may be added under the automatic gate arm to discourage pedestrians from walking or ducking under it. In the Dallas LRT system, pedestrian automatic gates with skirts are used at two LRT crossings near an elementary school. Figure 42 illustrates examples of placement of pedestrian automatic gates.

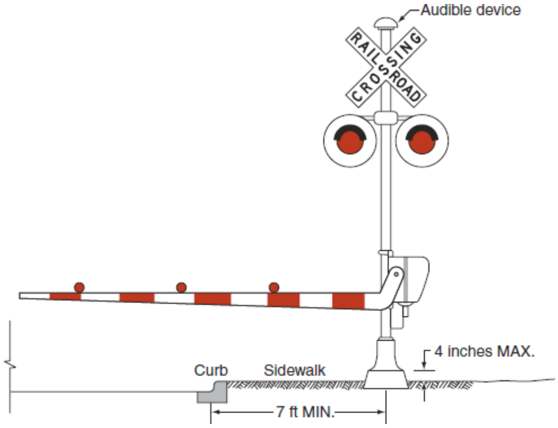


Figure 40. Example of shared pedestrian/roadway gate (MUTCD figure 8C-5)

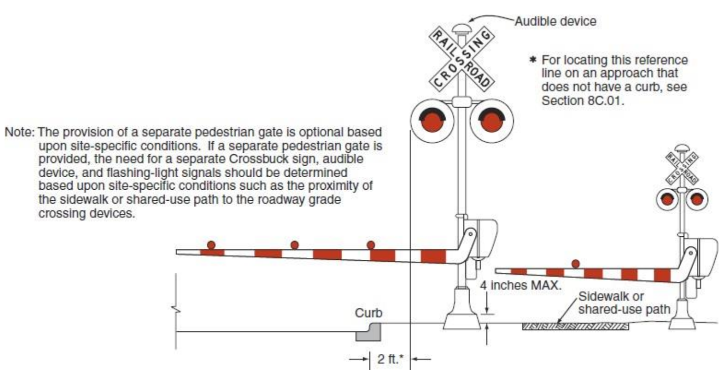


Figure 41. Example of separate pedestrian gate (MUTCD figure 8C-6)

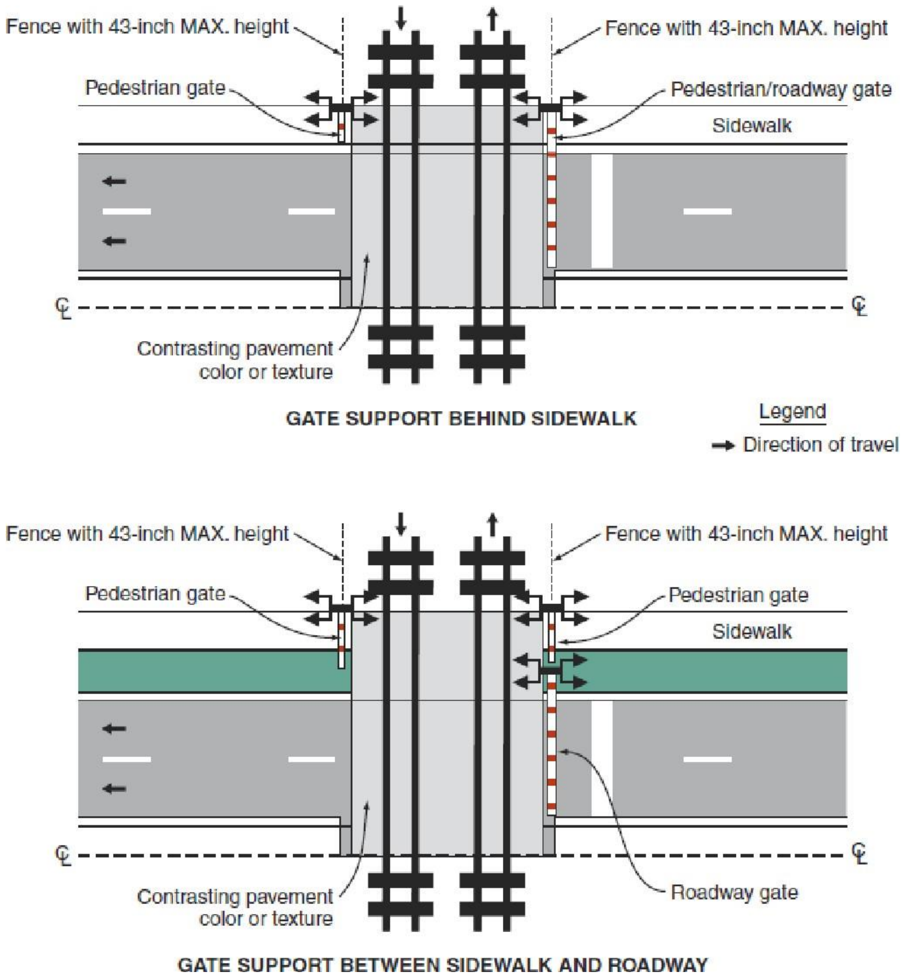


Figure 42. Examples of placement of pedestrian gates (MUTCD figure 8C-7)

To address the issue of pedestrians stopping on the tracks if an automatic gate lowers while the pedestrian is crossing the trackway, pedestrian automatic gate should be set back from the track a distance that would accommodate a wheelchair. This provides pedestrians with a refuge area between the track and gate to wait safely.

Manual Swing Gates. Manual swing gates may be installed across pedestrian and bicycle walkways to alert pedestrians to the LRT tracks by forcing them to pause before crossing. Swing gates require pedestrians to pull a gate to enter the crossing and to push a gate to exit the protected track area; therefore, a pedestrian cannot physically cross the tracks without pulling open the gate. The gates should be designed to return to the closed position after a pedestrian has passed.

Swing gates can be used in conjunction with active warning devices (e.g., flashing light signals and bells). Figure 43 illustrates example swing-gate layout that is included in Chapter 8C of the MUTCD.

In addition to forcing pedestrians to perform a physical action before entering the trackway, swing gates provide a positive barrier and an extra level of comfort for pedestrians at higher speed LRT crossings (16). A survey of pedestrians using swing gates at the Imperial-Wilmington station on the Los Angeles LRT system (Long Beach Metro Blue Line) indicates that 77% of those interviewed believe the pedestrian crossings are safer with the gates and 90% felt that swing gates should be installed at all Metro Blue Line stations where pedestrians cross the tracks (16).

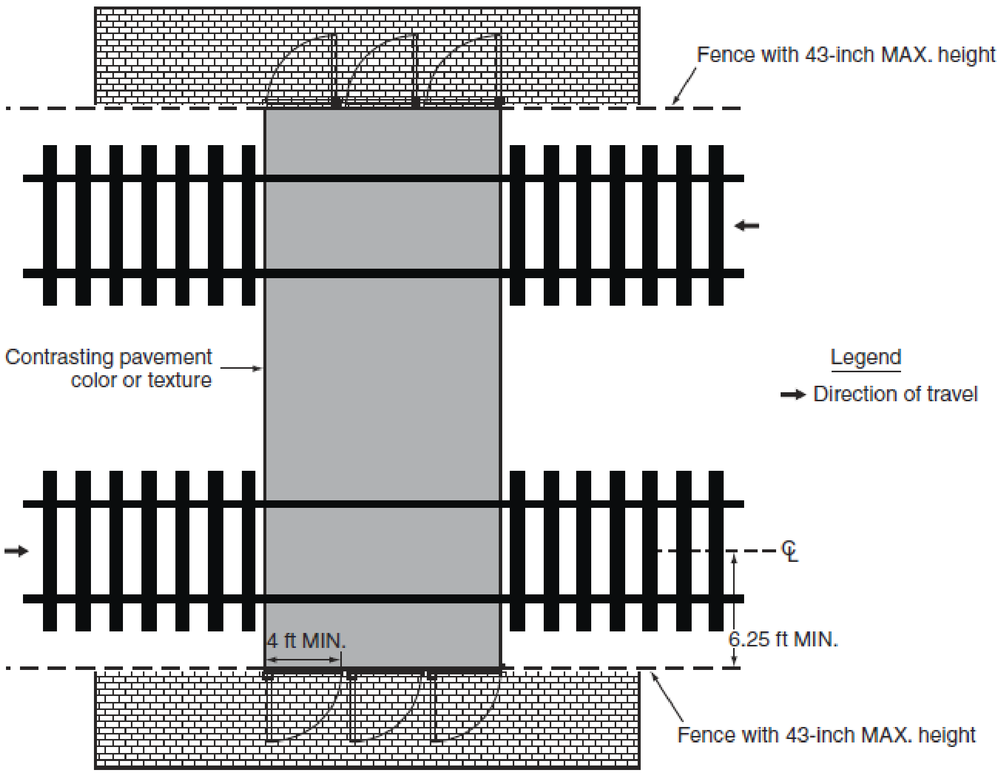


Figure 43. Example of pedestrian swing gates (MUTCD figure 8C-8)

In general, swing gates should be installed at locations where pedestrians are likely to dart across the tracks without looking both ways. Irwin (21) suggests using pedestrian swing gates where:

- Pedestrian sight distances are restricted.
- There is a high likelihood that persons will hurriedly cross the trackway.
- Channeling or other barriers reasonably prevent persons from bypassing the gates.
- Adequate provisions for opening the gates by disabled persons can be provided.

Typical locations for swing gates include crossings at LRT stations, where pedestrians may forget about LRVs after alighting one either at or near a transfer station, and where they may rush to board another mode of transportation. Examples of swing-gate installations at different LRT systems are shown in Figures 44 through 46.

5.3.1.4. Channelization

Pedestrians tend to take the shortest route to their destination, often crossing the LRT trackway at locations that are not equipped with safety treatments. In a report for the California Public Utilities Commission, Clark (9) reports that "pedestrian grade crossing design is only effective if pedestrians actually cross at the designated point and take a path that allows them clear observation of the warning devices." Channelization treatments provide control over pedestrian movements at LRT grade crossings in order to manage the potential conflicts between pedestrians, cyclists and LRVs. Some channelization treatments are used to provide safe space for pedestrian queuing.

Examples of channelization devices include pedestrian fencing & landscaping, offset pedestrian crossings (Z-crossings), and pedestrian refuge areas.

Fencing and landscaping. Fencing and landscaping are used to channel pedestrians to legal crossings at areas where errant or random pedestrian crossings of the trackway are known to occur. In addition, fencing and landscaping, along with signage and markings, help define the LRT alignment as a 'special space' with a high level of risk. The length of fencing should be based on an analysis of pedestrian destinations and travel patterns. In general, fencing should extend at least 25 feet either along the LRT right-of-way or along the pathway. Any gap between the fencing and warning devices should be minimized.

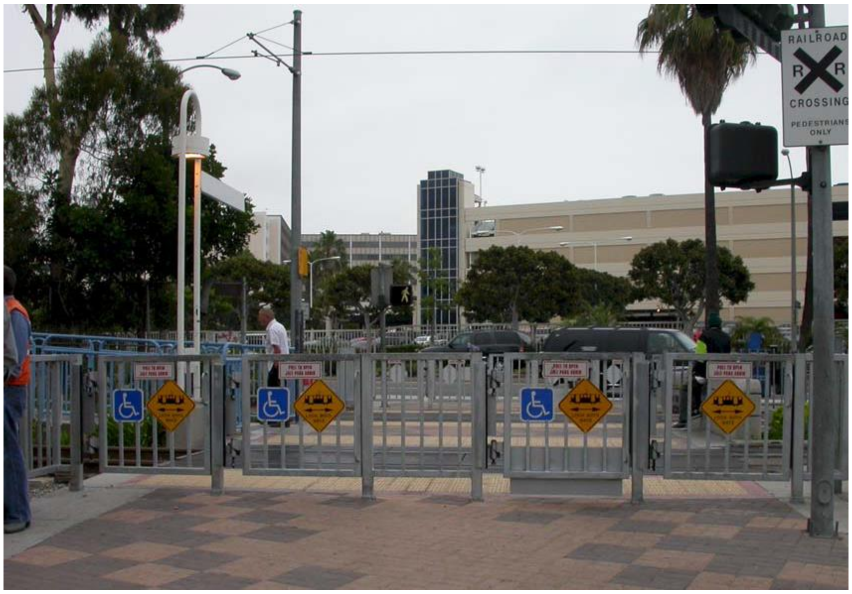


Figure 44. Pedestrian swing gates, Los Angeles, CA

Figure 45. Pedestrian swing gates, Tri-Met LRT, Portland, OR

Figure 46. Pedestrian automatic gates in combination with pedestrian swing gates, Mountain View, CA

Physical channelization is necessary for the effective operation of all types of automatic or manual pedestrian gates. When pedestrian automatic or manual gates are present, pipe-rail fencing should be placed between the sidewalk and the roadway to prevent pedestrians from easily walking around the pedestrian gate by stepping off the curb.

In order to prevent trespassing along the LRT right-of-way, it is recommended that fence heights be greater than 4 feet, and preferably 8 feet high, in order to act as a significant barrier to pedestrians. However, the fence height may need to be limited near LRT grade crossings to maintain sight lines along the tracks.

In determining the appropriate fence type, the designer should consider the issues of vandalism, difficulty of climbing the fence, and the construction and maintenance costs. While typical chain link fencing is cheaper than other types of fencing, it is not generally recommended because of the higher maintenance cost and lower vandal resistance compared to other types of fencing.

It is important to leave adequate room between the fencing and the LRV dynamic envelope so that pedestrians will not be trapped within the dynamic envelope. According to Clark, when pedestrian channelization using fencing and landscaping is combined with automatic gates, an exit device must be provided (9).

Figures 47 through 50 illustrate several types of pedestrian fencing and landscaping currently used for channelization of pedestrians and trespasser prevention.

Figure 47. Pedestrian fencing and landscaping in a downtown area with significant pedestrian traffic, Hudson–Bergen LRT, NJ

Figure 48. Pedestrian fencing near stadium stop, Muni's T and N lines, San Francisco, CA

Figure 49. Pedestrian fencing, DART, Dallas, Texas

Figure 50. Example of pedestrian taking the shortest route to destination

Offset pedestrian crossings. Offset pedestrian crossings, commonly referred to as Z-crossings, are passive treatments designed to channelize pedestrian movements so that pedestrians and bicyclists are forced to face the direction of oncoming LRVs as they cross the tracks. As shown in Figures 51 and 52, fencing and/or pedestrian barriers are installed to direct pedestrians to walk facing oncoming LRVs before entering the trackway.

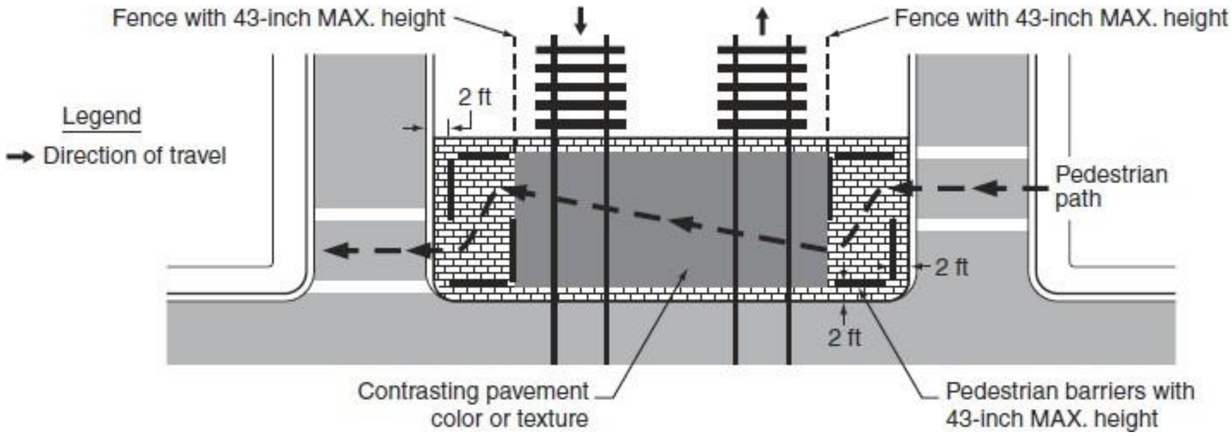


Figure 51. Pedestrian barriers at an offset grade crossing (MUTCD figure 8C-9)

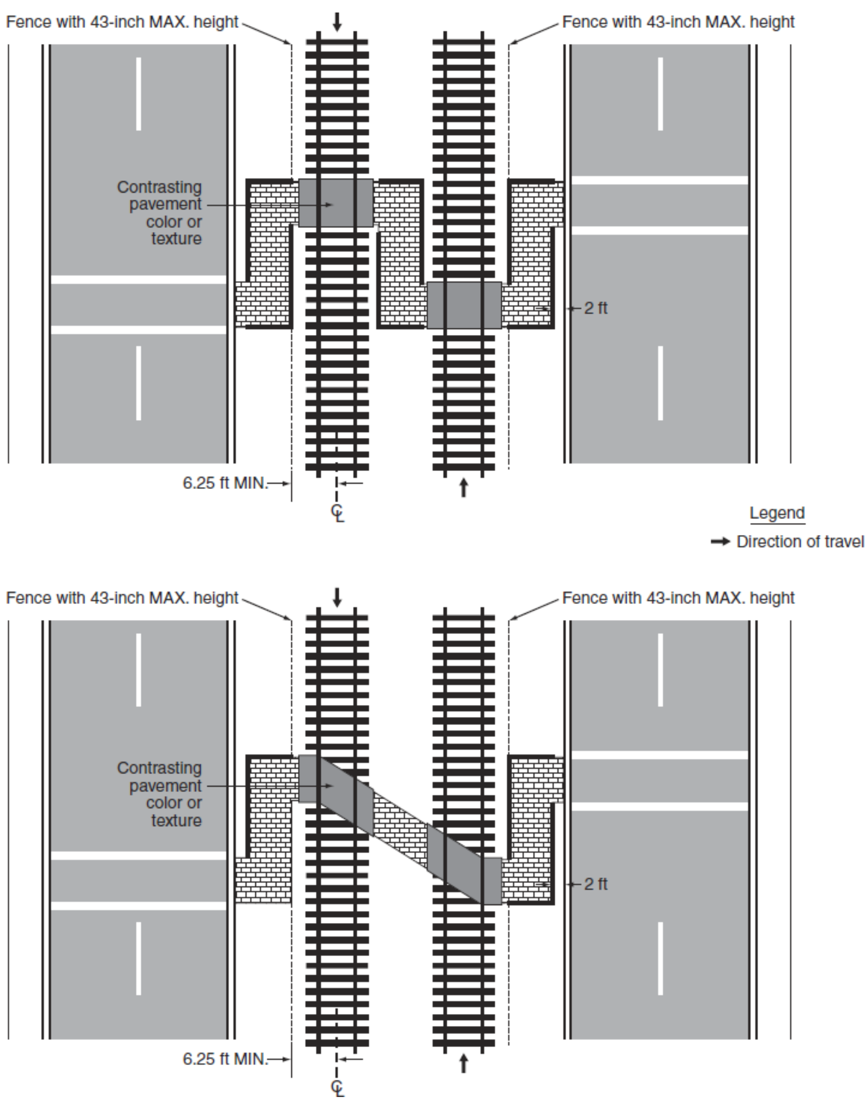


Figure 52. Pedestrian barrier installation at an offset non-intersection grade crossing (MUTCD figure 8C-10)

Offset crossings should be used only at pedestrian crossings with adequate sight distance. If pedestrians are turned to face approaching LRVs but cannot see them because of obstructions, the Z-crossing becomes useless. Furthermore, Z-crossings should not be used if LRVs operate in both directions on a single track because pedestrians may be looking the wrong way. Therefore, Z-crossings are not suitable near end-of-the-line (terminal) LRT stations, beyond the track crossover, or where LRVs routinely reverse-run into or out of a station. Examples of offset pedestrian crossings are shown in Figures 53 and 54.

Figure 53. Offset pedestrian crossing at an LRT station Hudson–Bergen Line, NJ

Figure 54. Offset pedestrian crossing, UTA Metro Salt Lake City, UT

Pedestrian Refuge Areas. Pedestrian refuge areas should be made available at pedestrian crossings on median-running LRT alignments where pedestrians are required to cross one set of traffic lanes, LRT tracks, and another set of traffic lanes to go from one curb to the other. As shown in Figure 55, each crossing is separated into a distinct movement, and pedestrians are not left standing on the tracks, or in the roadway, when a train approaches. The pedestrian refuge area should be clearly defined with contrasting materials.

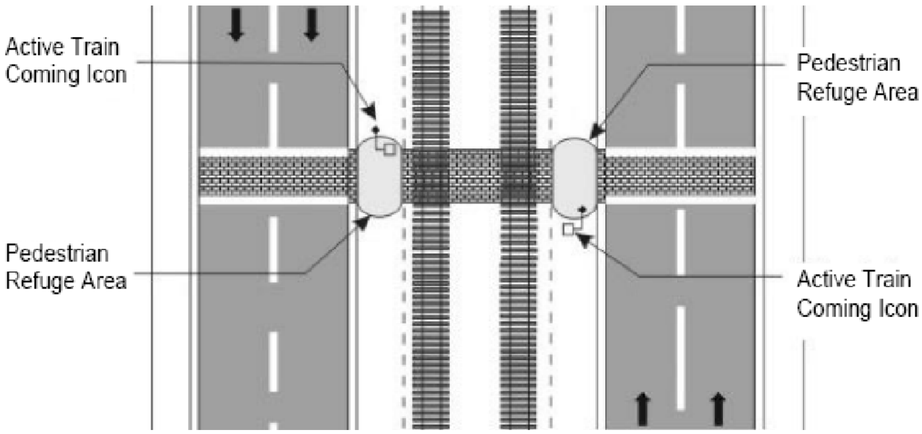


Figure 55. Pedestrian refuge area

5.3.1.4. Markings

Markings are changes to the pavement appearance or texture to delineate the LRT right-of-way or the LRV dynamic envelope. Major marking types include pavement and curb markings, delineators, colored pavements, and textured pavements. The main function of pavement markings is to alert motorists, pedestrians, and cyclists to the possible presence of an LRV so that they can be prepared for its arrival or passing.

Markings that must be visible at night should be retroreflective unless ambient illumination assures that the markings are adequately visible. Pavement markings and texturing require ongoing maintenance. They are effective in areas where snow and/or ice do not cover the markings. Rain can make markings difficult to see particularly at nighttime.

Dynamic Envelope Markings. As illustrated in Figure 56, the dynamic envelope indicates the clearance required for the LRV overhang resulting from any combination of loading, lateral motion, or suspension failure. The width of the dynamic envelope varies based on the type of LRV in use and whether it is traveling on a tangent or curved track. As shown in Figure 57, the dynamic envelope is wider on curves than on tangents. According to Section 8B.29 of the MUTCD, the dynamic envelope pavement markings should be placed on the highway 6 feet from and parallel to the nearest rail unless the operating LRT agency advises otherwise. The pavement markings for indicating the dynamic envelope shall comply with the provisions of the MUTCD Part-3 and shall be a 4-inch normal solid white line or contrasting pavement color and/or contrasting pavement texture.

In semi-exclusive LRT alignments, the dynamic envelope markings may be along the LRT trackway between intersections where the trackway is immediately adjacent to travel lanes and no physical barrier is present. In mixed-use LRT alignments, the dynamic envelope markings may be continuous between intersections. Figures 58 and 59 present examples of LRV dynamic envelope markings.

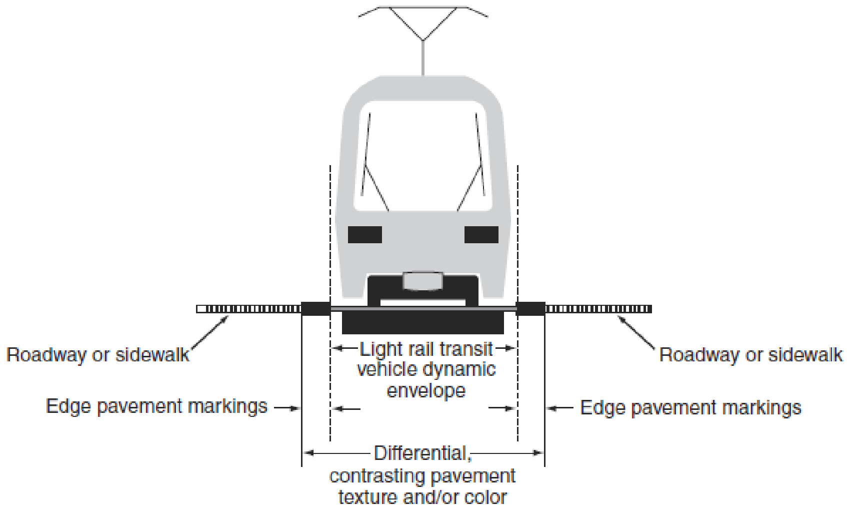
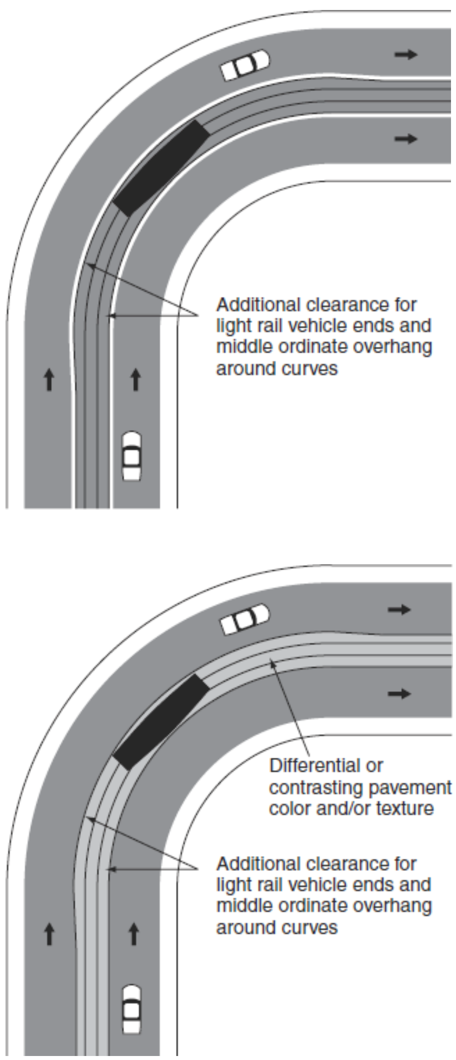


Figure 56. LRV dynamic envelope



A. Pavement Markings

B. Contrasting Color and/or Texture

Figure 57. Examples of LRV dynamic envelope markings for mixed-Use alignments (MUTCD figure 8B-9)

Figure 58. Textured concrete marking of LRV track area, Houston Metro, TX

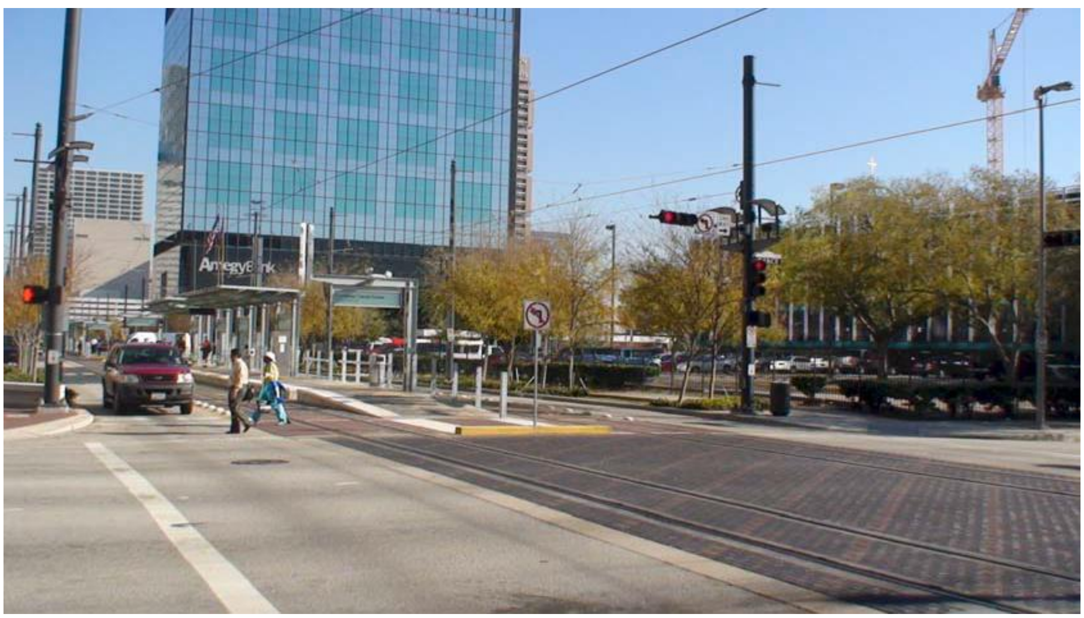


Figure 59. Colored, textured concrete marking of LRV track area, Houston Metro, TX

Word and Symbol Markings. Word and symbol markings on the pavement are sometimes used at LRT crossings and stations for the purpose of guiding, warning, or regulating pedestrian and cyclist traffic. Because pedestrians tend to look down toward the roadway surface as they walk, word and symbol markings can be particularly helpful to pedestrians and cyclists in some locations by supplementing signs and providing additional emphasis for important regulatory, warning, or guidance messages. Common word markings in use include “STOP HERE” and “LOOK BOTH WAYS”. Figures 60 through 63 show examples of word and symbol markings.

Figure 60. Painted "STOP HERE" on concrete pedestrian path before crossing, Tri-Met, Portland, OR

Figure 61. Painted "LOOK BOTH WAYS" on concrete pedestrian path before crossing, UTA, Salt Lake City, UT

Figure 62. Painted ″CROSS ONLY AT CROSSWALK″ marking and tactile strips at an LRT station, Salt Lake City, UT

Figure 63. Paint and texture on station platform edges, Hudson–Bergen line, NJ

Tactile and Textured Warning Strips. Tactile warning strips, such as truncated domes, are beneficial in warning visually impaired pedestrians of an upcoming hazard. Tactile treatments also provide a visual queue for other pedestrians of the safe stopping location outside of the LRV dynamic envelope. The use of tactile warning strips should not be limited to LRT station platforms, but also be used at all LRT grade crossings with sidewalks and where pedestrian activity is present or anticipated. If Americans with Disabilities Act–compliant tactile warning strips are not used, a change in texture or color of the trackway should be incorporated to delineate the safe zone for pedestrians. In either case, the tactile warning strip or striping should be located completely outside of the dynamic envelope of the LRV. Figures 64 through 67 illustrate examples of tactile waning treatments.

Figure 64. Textured concrete and tactile strips marking the pedestrian crossing area, DART, Dallas, TX

Figure 65. Raised yellow markers to warn pedestrians to stay off of the narrow strip of pavement between LRT tracks and the median station, MUNI, San Francisco, CA

Figure 66. Tactile treatments marking the trackway at pedestrian crossing Area, Baltimore, MD

Figure 67. Paint and texture on station platform edges, DART, Dallas, TX

5.3.1.5. Illumination of Grade Crossings
Poor visibility of a grade crossing and of the train within the crossing can contribute to serious accidents. Illumination systems are sometimes installed at or adjacent to a grade crossing in order to provide better nighttime visibility of LRVs and the grade crossing to motorists, pedestrians, and cyclists. Factors that should be considered in assessing the need for lighting systems include the visibility of LRVs and traffic control devices during hours of darkness, frequency of LRT operations conducted at night, the length of time a crossing is blocked, and nighttime crash history.

Recommended types and locations of luminaires for illuminating grade crossings are included in the American National Standards Institute's (ANSI) "Practice for Roadway Lighting RP-8," which is available from the Illuminating Engineering Society (53). Typically, light sources are directed to the sides of the LRVs to increase their conspicuity. Figure 68 illustrates a schematic of grade crossing illumination system.

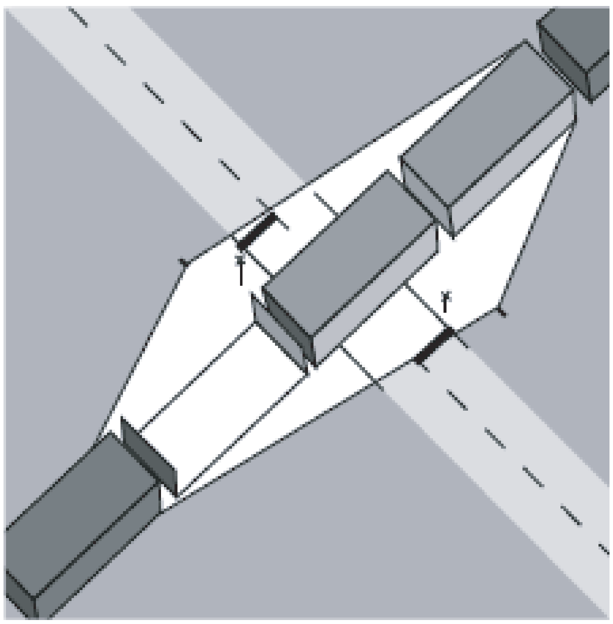


Figure 68. Schematic of rail-highway grade crossing illumination

5.3.1.6. Video Surveillance and Intrusion Detection
LRT agencies have continuously struggled with the issue of trespassing on the right-of-way and attempted suicide which can lead to very serious incidents. Several non-track circuit-based intrusion and obstacle detection systems (IODS) have been developed and field tested in recent years (54). These systems incorporate technologies such as magnetic, infrared, ultrasonic, and acoustic sensors, as well as radar and video detection. Some were developed specifically for the railroad environment, while others were intended for other applications such as perimeter security, military reconnaissance, and vehicle detection on roadways. While some technologies and systems have been made commercially available for operational use, many are still either being prototyped or field tested.

One of the notable IODS technologies is the intelligent video surveillance (IVS). Several manufacturers of IVS equipment offer commercial products that purport to be effective in detecting obstacles and intruders. For example, the San Diego Metropolitan Transit System implemented new video camera technology along the LRT alignment that allows the agency personnel to monitor the entire LRT system without setting in the video control booth. The San

Diego IVS system utilizes image processing software that analyzes surveillance video around the clock and only alerts personnel to situations that require attention.

Another example of IVS is the Florida DOT Advanced Warning Alerts for Railroad Engineers (AWARE) Pilot Program, which was specifically developed for railroad grade crossing applications. This project combined an automated video monitoring system with a global positioning system-based train location and communication system. This combination allowed for real- time communication between monitoring equipment at the crossing and an informational system on board specially equipped trains. Figure 69 shows the video monitoring and onboard systems.

Wireless sensor networks are among the promising emerging technologies for monitoring entire rail corridors. This technology employs a mesh of low power wireless sensors, as illustrated in Figure 70, to detect, locate, and characterize vehicles and people on the trackway. The information is communicated in real-time from the wayside sensor network to warning devices on board the train, thus maximizing the use of positive train control (54).

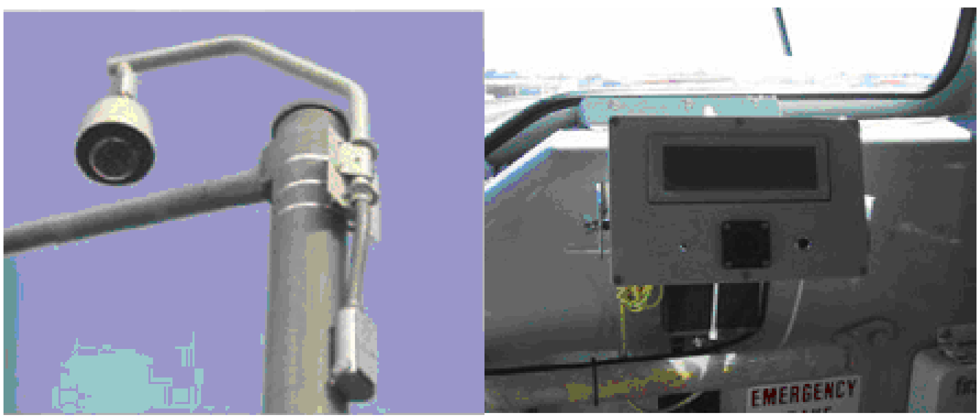


Figure 69. Video monitoring and on-board information systems, AWARE Project

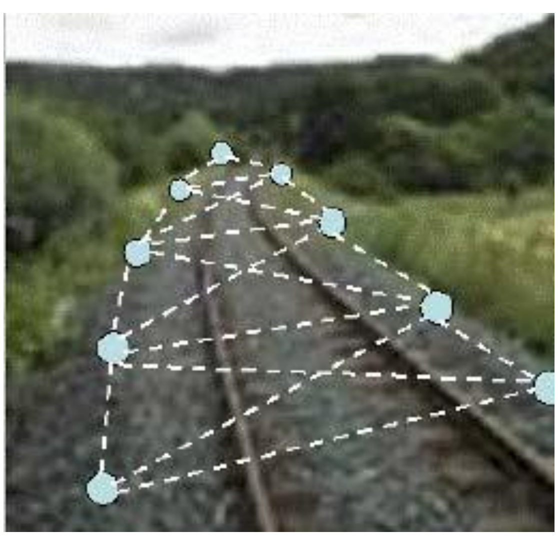


Figure 70. A wireless sensor network along trackway

5.3.1.7. Reducing Visual Clutter and Information Overload

Conservative use of warning and regulatory traffic control devices at LRT crossings is recommended. If used to excess, warning and regulatory traffic control devices lose their effectiveness. Most roadway users cannot read and process so many signs at a single location, especially when they are used in conjunction with active warning devices such as flashing light signals and automatic gates. The most typical result of placing so many signs so close together is motorist and pedestrian confusion and total disregard for the intended messages.

5.3.2. Education and Enforcement Programs

Lack of perception of the risks associated with unsafe actions and behaviors at LRT grade crossings and along LRT right-of-way is one of the primary causes of collisions between VRUs and LRVs. Therefore, public education programs are essential to ensure that VRUs are informed about the dangers associated with LRT operation and how to safely traverse LRT grade crossings.

It is also important to address those pedestrians who deliberately trespass on the right-of-way, ignore control devices at grade crossings, and knowingly violate the law. This can take the form of law enforcement and fines, or it can take the form of positive determent (e.g., station signs and advertisements that thank the community for helping the LRT agency make this our safest year).

This section presents synthesis of the literature related to education programs and outreach campaigns to educate the public about their duties and responsibilities at LRT crossings and along LRT alignments. It also presents available information on police enforcement of LRT safety laws at locations where reports indicate patterns of pedestrian violations.

5.3.2.1. Education Programs

A wide variety of education and outreach programs are available for addressing the safety of VRUs in LRT environments. Depending on local conditions and the types of existing and anticipated safety issues, each LRT agency should conduct a needs assessment to identify the short and long-term public education and outreach goals. This will help the organization establish priorities and utilize resources effectively.

In determining public education needs, the following types of programs should be considered:

- On-going, grade crossing public education programs tailored to at-risk groups of different demographics.
- A new-start safety education program to promote safe behavior and ensure VRUs understanding of the hazards before a new LRT operation starts.
- Programs that focus on trespass laws and the tragic consequences of trespassing on the LRT right-of-way, and suicide.

To meet the identified public education needs, each LRT agency should develop a plan for public education and outreach. The plan should outline the responsibilities for selecting and developing educational materials, target audiences and locations, activities that are planned for next year, and the financial and staff resources needed to implement the plan. The plan should be a living document that is updated regularly.

Target Audience. Perhaps the most appropriate audience for public education would be the LRT passengers and people who live, work, or go to school within, say, a mile and half of the LRT tracks. The demographics (e.g., age, gender, etc.) of these VRUs subgroups can be assembled using the Census Bureau data and GIS map of the area. In addition, the LRT agency should identify high-risk locations and corridors, for example, locations where large numbers of riders/pedestrians work, shop, or go to school. Possible sources of information include LRT operating data and schedules, fare collection data, and police collision reports. LRV operators also can be surveyed to identify areas where trespass activity is high, for instance, locations where people create shortcuts across the railroad right-of-way or through fenced corridors.

There is also need for determining the origins of VRUs so that the education programs can be focused on these locations (e.g., schools, workplaces, shopping malls, etc.) as well as provide educational material (billboards, signs) near or along the routes to the LRT system. It is also important to assess any multi-lingual requirements of the educational messages if a significant number of the target pedestrians' first language is not English.

Public education materials do not necessarily have to be focused on everyday users of the system. For example, it may be desirable to develop educational materials directed toward nonresidents (tourists, businesspeople, and other nonresidents who visit cities with LRT systems) (2). Maps, routinely distributed at rental car offices, might be reprinted to highlight the local LRT system and rail safety. Similarly, safety brochures could be developed for use in hotels where tourists and businesspeople are likely to stay, or at convention centers where large numbers of visitors who may be unfamiliar with LRT are present.

Educational Materials. Several educational materials have been developed by OLI (Operation Lifesaver, Inc.) and various rail transit systems including print brochures, video presentations, cartoons, activities, poster artwork, and public service announcements for television, radio, internet, and print media (billboards, magazines, newspapers, etc.). These materials can be licensed to any rail transit agency that might be interested in adapting them in its education and outreach programs. Marketing research with focus groups indicates that the effectiveness of educational materials can be enhanced significantly by including local information such as station names, transit system routes, and site-specific photos and videos of trains operating in local community settings. Research also shows that the educational materials and messages of all rail transit systems should always contain a few identical, basic safety messages such as "Look, Listen and Live" and "Stay Off! Stay Away! Stay Alive!"

Recognizing that traditional rail safety education programs are not always transferable to light rail transit, the FTA Office of Safety and Security has teamed up with OLI to develop a toolkit on light rail safety for transit agencies. More than two dozen transit agency professionals and outside experts participated in developing the LRT education materials. Some of the basic governing principles that were agreed to include:

- Flexibility – transit agencies should be able to implement the educational materials as is or customize such materials without incurring the start-up costs of development, graphic design, research, and testing.
- Scalability – the materials should be modular to allow agencies to adopt the product without change, or to pick and choose among its components to fulfill their local needs.
- Emphasize smart choices rather than dictate rules (although articulation of rules would obviously be part of it).
- Inform without scaring potential customers away from LRT.
- They would eventually have to be multi-lingual – Spanish was identified as an immediate need.

The developed LRT safety education materials were packaged in a presenter's kit that covers a youth program, an adult program, and a template speech to be used in making presentations to target audiences. The youth program includes a cartoon, activities (books and a full set of interactive activities that sneak safety education into games for kids from kindergarten to middle school), and artwork posters. The cartoon targets 4th to 8th graders and features a light rail mascot, "Earl P. Nut," an American Red Tail Squirrel whose adventures around light rail tracks and trains are very educational (48, 49). Earl has a desire to see the United States, but his family has a tragic tradition of ending up as roadkill under a variety of modes of transportation. Being smart and savvy, Earl studied all the safety rules and interacts with a numerous characters (including other transit agency mascots) as he travels around the country.

The adult program includes brochures, fact sheets and frequently asked questions, posters and other artwork, PowerPoint presentation, public service announcements, and examples of light rail systems in various communities. Figure 71 shows a tri-fold brochure summarizing LRT safety tips.

The appeal, effectiveness, and long-term retention of the presenter's kit of materials were the subject of a nationwide assessment that involved focus groups and surveys. Key findings of a focus group evaluation of the different materials include (49):

- The cartoon worked very well for 4th to 6th graders, moderately well with 7th graders, and was not appealing to older kids, though they did remember its messages two weeks later.
- Activities were very popular with all ages and having a variety of games was important. Even older kids paid attention once the interactive activities were introduced.
- The ACORN mnemonic (ALWAYS look both ways, CROSS only at crosswalks, OBEY all signs and signals, RAILROAD tracks are for trains, NEVER try to outrun a train) was very effective with all age groups and all participants remembered it.
- Poster artwork was good for the kids, but posters should not be used as basis for a key part of the presentation. Younger kids found presentations based only on posters to be boring.
- Older kids prefer real live humans in real live situations over cartoon animals in video presentations. Examples include the OLI's teenage live action video telling the real story of a teenager killed at a crossing, and the LACMTA's light rail video for teens.

Many of the FTA/OLI light rail materials are bilingual (English and Spanish) and can be found at Operation Lifesaver's website. Figures 72 and 73 show the homepage and the main menu of OLI website. The program is now in use at light rail agencies around the country, many of which team with OLI corps of trained presenters. Figure 74 shows example of educational materials produced by OLI to target distracted pedestrians.

In addition to OLI educational media, several LRT agencies developed their own educational materials for their public education and outreach programs. Notable examples include the Los Angeles County Metropolitan Transportation Authority (LACMTA), Santa Clara Valley Transportation Authority (SCVTA), Denver Regional Transit District (RTD), New Jersey Transit (NJT), Tacoma Sound Transit (ST), Utah Transit Authority (UTA), Minneapolis Metro Transit (MT), San Francisco Muni, and Southeastern Pennsylvania Transportation Authority (SEPTA).

The LACMTA Metro Experience mobile theater shown in Figure 75 travels to different community events to target individuals who may not belong to traditional groups or organizations. Metro Experience uses videos to offer life-saving safety messages for all age groups in a fun and informative way. These safety presentations deliver lasting impressions about the consequences of careless behavior around an operating rail system.

Frequently Asked Questions

What's the difference between light rail trains and other trains?
Definitions vary, but most light rail trains operate with electric engines and have more frequent service, carry a higher number of passengers, and operate with fewer train cars than conventional passenger trains such as Amtrak.

Why are light rail trains so quiet?
Light rail trains run on electrical power drawn from power sources outside of the train (usually delivered by overhead electric power lines) or diesel electric engines inside the train car. They are much quieter than most locomotive engines associated with conventional freight or passenger trains.

If a train is far away or standing still, why can't I cross at an unmarked area of the track?
A train moving at 55 mph toward you will appear to be moving much more slowly than it really is, and one going slowly may appear not to be moving at all.

Also, it takes a train a lot longer to stop than it takes a car to stop and there is no such thing as "swerving" for a train.

The ONLY safe place to cross is at a designated crossing. Even at those crossings be sure to look both ways, double check for trains in both directions. ALWAYS mind any signals or warning devices.

How often do light rail trains operate?
Different systems have different schedules, and in some areas trains literally every few minutes.

Remember that light rail trains can come from either direction.

Any time is train time – always expect a train!

Safety Tips Around Light Rail Trains

Remember the **ACORN** rules!

Always look both ways.

Cross only at designated crosswalks.

Obey all signs, warning lights, and signals.

Railroad tracks are for trains only – don't ride your bike, jog, or skateboard on them.

Never try to outrun or "cut off" a train.

Get Real about Light Rail.

OPERATION LIFESAVER

More information about rail safety can be found by contacting Operation Lifesaver:
www.oli.org

Key Safety Tips Around Light Rail Trains

PROVIDED IN THE INTEREST OF SAFETY

Safety Tips Around Light Rail Trains

Since light rail trains operate within cities, their tracks are frequently crossed by roads, streets, and pedestrian walkways. In some areas, light rail tracks share the roadway with automobiles, motorcyclists, and bicyclists. That's why at Operation Lifesaver, we encourage everyone to "Look, Listen, and Live!"

LOOK
- Be alert around train stations.
- Be careful on platforms.
- Watch for other traffic when disembarking from a train.
- Watch for trains when crossing tracks in a motor vehicle, on a bicycle, or on foot.
- Obey all signs, signals, and lights.

LISTEN
- Light rail trains operate frequently, from either direction, and with often with very little noise, so listen CAREFULLY.
- Be sure you can hear whistles, bells, or other warnings whether on foot, on a bike, on a motorcycle, or in a car.

LIVE
- Know the basic safety guidelines.
- Talk about safety awareness with family & friends.

Get Real about Light Rail.

ANY TIME IS TRAIN TIME.
- Trains can run after-hours as well as during scheduled service time.
- They can run on any track, in any direction, at any time.
- Never be in such a hurry that you forget you are approaching the tracks.

TRAINS CAN'T SWERVE.
Light rail trains do not have a steering wheel. They must follow the track, and the only thing the light rail train operator can do is apply the emergency brake.

Steel wheels can not grip steel tracks the way rubber tires grip asphalt. While a car traveling 55 mph can stop in about 200 feet, a light rail train may need as much as 600 feet to stop – the length of two football fields.

Obey the pedestrian signals, lights, or warning signs. Nearly half of all rail collisions occur because people ignored the lights, bells, and gates at railroad crossings.

Watch for the second train! Once a train passes, take a second look for other trains traveling in the opposite direction (or hidden behind the first train.)

WATCH THE OVERHANG.
Light rail trains are wider than the tracks by at least three feet on either side.

To be safe, stand, drive, park your car or ride your bike OUTSIDE of marked lines on the pavement. Where you are unsure of the markings, stay at least three feet away from the tracks.

When driving, do not "anticipate" a turn across the tracks in a way that brings you within the overhang. Make sure anything hanging from you or jutting out from your car is not over the marked line. You could get caught by a passing train and be dragged.

NEVER sit on the edge of the platform. There's not enough room in the gap between the body of the train and the platform.

DRIVE CAUTIOUSLY.
An optical illusion makes oncoming trains appear to move more slowly than they do – so it is difficult to judge the distance and speed of an oncoming train accurately.

Do not anticipate a turn in a way that inadvertently leaves you on the tracks or within the train's overhang. Do not cut in front of a train; remember, trains can not stop suddenly or swerve the way cars can.

Because it is often hard to see what's coming on the other side of the train, ALWAYS look twice.

Cross only at designated crossings.

Obey all signs, crossing arms, lights, and signals. Inattention or failure to obey can lead to:
- Costly fines
- Points
- Possible incarceration
- Injury or death

TRACKS ARE FOR TRAINS.
Never bicycle, skateboard, jog or walk on the track. Light rail trains are fast, frequent and quiet and can come from either direction without warning.

Bridges and tunnels do not have enough clearance for both you and the light rail train. Stay off of and away from train tunnels and bridges.

Your ability to vacate the tracks in front of an oncoming train is limited. It is possible to get a wheel or a shoe caught in the track – a twist and fall could injure you or even leave you trapped in front of an oncoming train.

Being on the tracks except where designated is illegal, subjecting you to costly fines or even incarceration.

Figure 71. OLI trifold brochure summarizing LRT safety tips

Figure 72. OLI light rail homepage

Figure 73. OLI light rail website main menu

Figure 74. Print media PSA produced by OLI to raise awareness of distractions

Figure 75. LACMTA metro experience mobile theater

Presenter Preparation. Knowledgeable and well-trained presenters are critical to the success of LRT safety education and outreach programs. In a paper entitled "Trained Presenters Make the Difference," Isabel Kaldenbach -- OLI's national director for light rail safety education -- reports that the presenter's level of training is as important as the materials they present (49). She also points out that "presenters who were trained speakers but did not have a comfort level with the specific material (in this case, the specific rail transit agencies involved as well as specific information about rail safety) scored far more poorly than those familiar with the local systems and with rail safety."

Presenters may come from all walks of life including the transit agencies own employees, other transportation providers, law enforcement, public sector organizations, celebrities, and community volunteers who have an interest in public safety. As a prerequisite, presenters should receive basic training in rail safety, and should be familiar with the local rail operation and the community it serves in order to effectively present the material and answer questions from the audience. In focus group tests conducted nationwide, it was found that presenters who were unable to answer questions and give detailed backup information about certain safety rules that were presented lost credibility almost immediately (49).

Operation Lifesaver, Inc. has an established national program for training and certification of volunteer presenters which is available through the OL coordinator in each state. The program includes a one-day training course as well as a train the trainer course. Rail transit systems are encouraged to take advantage of the training opportunities offered through OLI. Whether this training venue or another is pursued, it is important to maintain uniformity and to ensure that trained presenters are well prepared to deliver accurate safety information to the public and answer questions.

Public Education Venues. Safety education and outreach programs vary by type and intensity. The following venues have been successfully utilized by Operation Lifesaver for providing safety education:

- Formal classroom presentations – Course materials are presented in a classroom environment at schools and community centers by volunteer presenters from various sources.
- Web-based presentations – Safety materials are available online for interested users, e.g., students.
- Sponsored in-house events – Safety information may be disseminated using signboard displays, educational videos, safety brochures and other promotional items (e.g., pens, key chains, notepads, etc.) at stations.
- Special events – Video presentations, displays, and handouts at safety booths staffed by Operation Lifesaver volunteers at area malls, county and state fairs, and community events.
- Celebrity spokespersons – Solicitation of local celebrities to promote grade crossing safety and rail trespass prevention using public service announcements for television.

Regardless of the selected venue, safety education initiatives should be repeated on a regular basis. Annual renewal of presentations and initiatives is recommended.

Program Evaluation. Program evaluation is an important component of any safety education program. Anecdotal reports of the benefits of rail safety education and outreach programs in terms of reductions in incidents and risky behavior by pedestrians and cyclists are available. The success of safety education is highly dependent on educating the VRUs subgroups most likely to engage in the risky behavior.

In two research papers entitled "Why has Safety Improved at Rail-Highway Grade Crossings?" (47) and "Does Public Education Improve Rail-Highway Crossing Safety?" (46), the authors explored the reasons behind the significant decline in the number of collisions and fatalities at rail-highway crossings despite considerable increases in both highway and railroad traffic volumes. Using negative binomial regression, the papers disaggregated the safety improvement during the period 1975 to 2001 into its constituent causes. The analysis concluded that increasing Operation Lifesaver public education activities in a state reduces the number of incidents with a point elasticity of -0.11 (46). In addition, the authors estimated a remarkable 100:1 benefit-cost ratio for Operation Lifesaver rail safety education and outreach programs (47).

5.3.2.2. Enforcement

No matter what type of warning or control device is installed at LRT grade crossings, some pedestrians will tend not to heed the warnings. Laws pertaining to LRT grade crossings and right-of-way violations are likely to be ineffective if they are not enforced. Enforcement campaigns can be designed to target illegal grade crossing, jaywalking, trespassing on right-of-way, and distracted pedestrians near LRT tracks. Typical enforcement strategies include assigning transit and local police officers to enforce grade crossing safety, stationing marked patrol cars at randomly selected crossings every day, traffic cameras, and video surveillance of rail tracks coupled with audio warnings issued to trespassers.

Grade crossing safety research indicates that education and engineering should come before enforcement (58). Because of the difficulties in modifying established behaviors, the largest long-term safety impacts can be gained from education, before unsafe practices become inherent (59, 60). For example, targeted enforcement campaigns against jaywalking have been carried out repeatedly by UTA police, but UTA staff has reported no long-term benefits (10). When the enforcement ends, pedestrians continue to violate the law. Only the immediate risk of a fine seems to be a deterrent.

6. CONCLUSIONS

Section 5 of this report presented physical treatments for improving safety of VRUs in LRT environments. The selection of a particular treatment for use at an LRT grade crossing or station should be based on an engineering study whose scope and complexity depend on local conditions. Factors that should be considered during device selection include the following:

- Pedestrian-LRV collision experience.
- Pedestrian volumes and peak flow rates.
- Train speeds, frequency of trains, number of tracks, and railroad traffic patterns.
- Sight distances available to pedestrians and LRV operators approaching the crossing.
- Skew angle, if any, of the crossing relative to the LRT tracks.

6.1. Recommended Practice

TCRP Report 69 developed a recommended practice for pedestrian treatment selection based on existing practices and key underlying factors that distinguish alternative conditions for implementation (2). The recommendation covers three types of physical treatments: warning devices, channelization, and positive control devices. Table 16 presents the recommendations for using active warning devices at pedestrian crossings, and Table 17 summarizes the recommended uses of positive control devices where such devices are required.

Table 16. Use of warning devices at pedestrian crossings

Pedestrian Crossing Location	Visual Warning Devices	Audible Warning Devices
Isolated pedestrian or bicycle path	LRV-activated LRT warning signs	Bell
Parallel to roadway along sidewalk (semi-exclusive Type b.1)	Red flashing light signals	Bell
Across roadway in marked crosswalk - adjacent to an intersection (semi-exclusive Type b.2)	Pedestrian signals	Audible pedestrian device

6.2. Guidelines for Safety Treatment Selection

Figure 76 presents a decision tree for selecting among VRUs treatments in LRT alignment types b.1 and b.2 (2). These are the only two alignment types with at-grade crossings and LRVs traveling at speeds greater than 35 mph. The decision tree defines the type of VRUs treatments that are recommended based on the following six criteria (decision points):

Decision Point 1 - Pedestrian facilities and/or minimum pedestrian activity present or anticipated: This decision point addresses locations where pedestrian facilities exist on both approaches to the LRT crossing, and/or minimum pedestrian activity exists or is anticipated. Pedestrian facilities include sidewalks, crosswalks, pedestrian-only or bicycle-only paths/trails, and station access routes. Where these facilities have been provided, it is assumed that some minimal level of pedestrian activity is present, and thus passive pedestrian control (e.g., Look Both Ways sign) is required.

Decision Point 2 - LRV speed exceeds 35 mph: This decision point addresses locations where the maximum operating speed of the LRV exceeds 35 mph. Active, LRV-activated warning devices (e.g., illuminated signs with graphic legends, flashing light signals, audible devices) should be provided at all pedestrian crossing locations where LRV speeds are greater than 35 mph.

Where active warning devices associated with the parallel vehicular crossing exist, such devices may satisfy some or all of the need for active devices for pedestrian movement. However, at isolated pedestrian crossings or bike path crossings, active devices should be provided to warn pedestrians of the greater risk associated with higher speed operation above 35 mph.

Decision Point 3 - Sight distance restricted on approach: This decision point describes pedestrian grade crossings where the available sight distance is not sufficient for pedestrians to see the LRV far enough down the tracks to complete the crossing before the train arrives at the crossing, or for the LRV operator to see the pedestrian and bring the train to a safe stop if needed.

Pedestrian automatic gates should be installed at pedestrian crossings where an engineering study has determined that the sight distance at the crossing is not sufficient. Section 3.3.4 presents discussion of safe sight distances at LRT grade crossings. If it is feasible to increase sight distance (e.g., widening the clear area on either side of the track or moving objects such as signal cabinets, communication rooms, and passenger ticket vending machines, which obstruct line of sight of portions of the crossing), such actions should be considered in conjunction with the decision to provide positive control.

Barrier channelization is also required at locations where the sight distance is not sufficient. The purpose of barrier channelization is to direct pedestrians to a location where sight distance is not restricted or to a crossing that is controlled by pedestrian automatic gates.

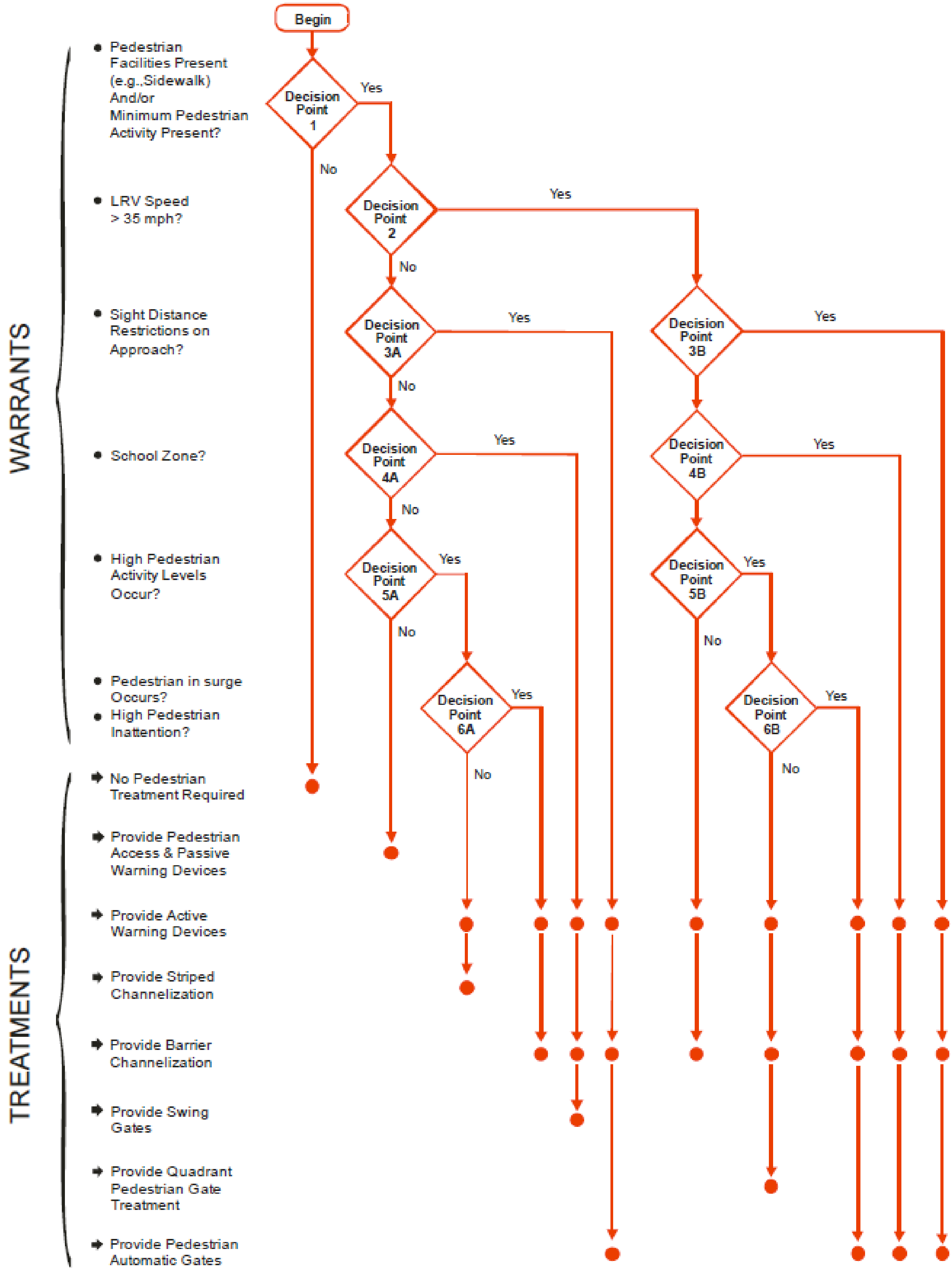


Figure 76. Decision tree for selecting among pedestrian treatments

Decision Point 4 - Crossing located in a school zone: For the purposes of this decision point, a school zone is defined as the area within 600 ft of a school boundary, and school routes with high levels of school pedestrian activity as defined in Decision Point 5. Within a school zone, barrier channelization is required to direct pedestrians to a grade crossing equipped with active warning devices and swing gates or pedestrian automatic gates.

At LRT grade crossings within a school zone, pedestrian automatic gates should be used where LRV maximum operating speed exceeds 35 mph. Active warning devices and swing gates may be used instead of automatic gates where LRV maximum operating speed does not exceed 35 mph.

Decision Point 5 - High pedestrian activity levels occur: LRT grade crossings with high levels of pedestrian activity are defined as locations where at least 60 pedestrians use the crossings during each of any 2 hours (not necessarily consecutive) of a normal day, or at locations where at least 40 school pedestrians use the crossing during each of any 2 hours (not necessarily consecutive) of a normal school day.

Active warning devices should be used at all LRT grade crossings where high levels of pedestrian activity occur. Furthermore, where the LRV maximum operating speed exceeds 35 mph and high levels of pedestrian activity occur, pedestrian automatic gates should be installed on the two quadrants that are occupied by motorist gates by either moving the motorist gate behind the sidewalk or adding an additional pedestrian gate. Where LRV maximum operating speed does not exceed 35 mph and high levels of pedestrian activity occur, striped channelization should be used. Barrier channelization should be used instead of striped channelization if there are surges in pedestrian flow rates or if pedestrian inattention is expected (see Decision Point 6).

Decision Point 6 - pedestrian surge occurs or high pedestrian inattention: This decision point is intended for locations where pedestrian volumes are extremely high during peak periods (e.g., transfer station locations), or near places of public assembly where pedestrian inattention is high (e.g., special event locations where pedestrian crowds and distractions are expected).

At pedestrian grade crossings where the LRV maximum operating speed does not exceed 35 mph and pedestrian surges or high pedestrian inattention may occur, barrier channelization should be installed to direct pedestrians to a crossing with active warning devices.

Where LRV maximum operating speed exceeds 35 mph and pedestrian surges or high levels of pedestrian inattention occur, pedestrian automatic gates should be installed in addition to the barrier channelization. For example, crossings near special pedestrian generators such as sports facilities, where crowds may encourage incursion onto the crossing, may warrant positive control regardless of sight distance. The objective is to provide a physical barrier between the LRT tracks and locations where pedestrians can safely queue.

In regard to decision points 5 and 6, high levels of pedestrian activity are those resulting in level of service in the LOS D to F range during peak periods Details of LOS assessment are described in Chapter 18 of the Highway Capacity Manual (61).

As indicated in the decision tree of Figure 76, there are several possible scenarios depending on the answers to the six criteria. In the least restrictive situation, i.e., a grade crossing with relatively low pedestrian volumes, where LRV speed does not exceed 35 mph, where sight distance is good, that is not located in a school zone, and where no other factors warrant special consideration, the recommended practice is to provide passive warning devices at the crossing. For the most restrictive situation, i.e., a grade crossing where LRV speed exceeds 35 mph, where sight distance is inadequate, the crossing is located in a school zone, or where pedestrian surges or high levels of pedestrian inattention occur, active warning devices and positive control are recommended.

6.3. Recommendations

Given the infrequent and random nature of LRV-pedestrian collisions, a meaningful measure of effectiveness for evaluating the impact of safety treatments is the number of risky pedestrian behavior incidents. Risky behavior incidents are those incidents where behaviors or movements made by the pedestrian present a threat of collision with a train, but no actual collision occurs. They include near-miss incidents and close calls. Risky behavior incidents are indicators of a location's collision potential. Because such incidents are more frequent than the number of collisions, they can be used in statistical analysis. It is recommended that transit agencies and the NTD collect data on risky behavior, evasive actions, and violations using video cameras at the locations where treatments will be implemented.

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APPENDIX A: LRT Collision Data

- **Portland Tri-Met**
- **Los Angeles County (LACMTA) Metro Blue Line**
- **Houston Metro**
- **Baltimore (MTA) Light Rail**
- **Salt Lake City (UTA) Light Rail**

Portland Tri-Met

Portland TriMet LRT Collisions - Annual

revised 10/20/06

Year	Pedestrian	Bicyclist	Motor Vehicle	Total	Train Hours	Train Miles	Avg Weekday Boarding Rides
1994	3	1	18	**22**	59,112	885,720	24,508
1995	3	1	23	**27**	59,268	886,440	27,350
1996	1	1	24	**26**	59,544	865,920	28,025
1997	6	1	26	**33**	59,751	893,520	30,417
1998	8	3	42	**53**	66,713	964,468	40,267
1999	10	3	41	**54**	130,231	2,237,688	62,308
2000	2	0	29	**31**	143,094	2,558,107	68,250
2001	10	4	28	**42**	144,674	2,590,668	73,758
2002	6	3	37	**46**	183,647	3,171,775	77,825
2003	13	2	33	**48**	192,520	3,271,824	81,042
2004	7	2	29	**38**	201,235	3,497,866	91,667
2005	2	4	34	**40**			98,250
2006	3	2	32	**37**			101,000
Total	74	27	396	**497**			
Annual Average	5.7	2.1	30.5	**38.2**			

Numbers of accidents include every incident of contact, including minor fender benders, clipped mirrors, and many other incidents in which no injuries were reported and material damage was minimal.

Train Hours and Train Miles are represented per fiscal year (July-June).

Additional variables not included are number of:
Track miles, Crossings protected by gates, Crossings protected by traffic signals, Train trips

Portland Tri-Met Fatal Collisions

Fiscal Year	Date
FY ′86	07/28/86
FY ′87	None
FY ′88	None
FY ′89	None
FY ′90	01/01/90
FY ′91	01/16/91
FY ′91	03/02/91
FY ′92	02/25/92
FY ′92	06/22/92
FY ′93	None
FY ′94	None
FY ′95	None
FY ′96	None
FY ′97	None
FY ′98	None
FY ′99	09/20/98
FY ′99	06/05/99
FY ′99	06/14/99
FY ′00	08/02/99
FY ′00	10/11/99
FY ′01	04/09/01
FY ′02	10/20/01
FY ′02	01/04/02
FY ′02	02/08/02
FY ′03	06/23/03
FY ′04	08/01/04
FY ′05	None
FY ′06	09/28/05
FY ′06	05/14/06

LOS ANGELES METRO BLUE LINE

Corporate Safety is responsible for the collection, maintenance, and distribution of the accident/incident data. This report, Summary of Metro Blue Line Train/Vehicle and Train/Pedestrian Accidents is part of the trending performed by LACMTA.

The Rail Operations Safety Department monitors and analyzes the trends and patterns. In the past, trending has resulted in implementation of grade crossing safety improvements such as the fiber optic trains signs along Flower Street and Washington Blvd, the four quad gate demonstration project, photo enforcement program, new legislation, and public education programs. Rail Operations Safety will continue to make recommendations and improvements to the rail system as necessary.

The following contributing factors codes are used in the report:

LT	Vehicle entered trackway from left turn lane.
RT	Vehicle entered trackway from right turn lane.
UT	Vehicle attempted to make a U turn on a street perpendicular to the trackway.
RS	Vehicle ran through a red traffic signal or stop sign.
FLB	Pedestrian violated flashing lights/bells.
AE	Encroachment by vehicle into the trackway, other than by turning onto the tracks in front of a train or by running through a red traffic signal or stop sign.
RG	Vehicle or pedestrian ran around a down crossing gate.
TR	Pedestrian trespassing on the right-of-way.
HR	Vehicle left accident scene without stopping
DR	Intoxicated driver or pedestrian.
ST	Two or more trains passing through the crossing.
SU	Suicide.
PD	Police Department vehicle involved in accident.
FD	Fire Department vehicle involved in accident.
SD	Vehicle or pedestrian traveling in same direction as train.
EB	Vehicle or pedestrian entered trackway in eastbound direction.
WB	Vehicle or pedestrian entered trackway in westbound direction.
NB	Vehicle or pedestrian entered trackway in northbound direction.
SB	Vehicle or pedestrian entered trackway in southbound direction.

The direction of travel of the MBL train is either northbound (track 1) or southbound (track 2). In the "Contributing Factor(s)" column, the geographical direction of travel of the vehicle or pedestrian is used.

There are two types of accidents, Train vs. Auto (TA) or Train vs. Pedestrian (TP). Incidents involving bicyclists are coded as TP; incidents involving motorcycles are coded as TA. Incidents involving objects are not included in this report. Incidents, which only involve mirror damage to either the Train or the vehicle, are noted in a separate table in the back of the report. Same for incidents categorized as possible pedestrian incidents. These incidents result in no pedestrian found at the scene when either the Operator or Supervisor investigates but no conclusion can be made as to whether an incident occurred or not.

Accidents with an asterisk (*) to the right of TA or TP are either new in this quarter or updates/corrections to previous reports.

METRO BLUE LINE ACCIDENTS BY SEGMENT & LOCATION

July 1, 1990 through June 30, 2006

LOS ANGELES STREET RUNNING

Loc No.	Location Description	Vehicle	Ped
0062	12TH ST	13	1
0066	ALLEY NR 12TH ST	4	
0072	PICO STATION PED		3
0075	PICO BLVD	16	1
0079	CAMERON LANE	11	
0084	DRIVEWAY @ 1348 FLOWER	2	
0086	DRIVEWAY @ 1360 FLOWER (GLOBE)	6	
0091	DRIVEWAY @ 1370/1374 FLOWER	5	
0092	DRIVEWAY @ CAL PRESS	2	
0099	VENICE BLVD	36	
0104	DRIVEWAY NORTH OF I-10 ON-RAMP	7	
0110	I-10 ON-RAMP	6	
0112	18TH ST	19	
0120	UNK FLOWER ST	1	
0123	WASH BLVD/FLOWER	5	
0130	HOPE ST	1	
0140	GRAND AVE	17	3
0144	OLIVE ST	17	
0144_0149	between Olive St and Hill St	1	
0149	HILL ST	9	
0156	BROADWAY	13	
0156_0163	between Broadway and Main St	1	1
0163	MAIN ST	18	
0170	LOS ANGELES ST	18	
0183	MAPLE ST	15	
0190	MAPLE CROSSOVER	1	
0198	TRINITY ST	10	2
0208	SAN PEDRO ST	25	
0215	SAN PEDRO PED		2
0219	SAN PEDRO STA	1	1
0234	GRIFFITH AVE	9	
0234_0254	between Griffith Ave and Central Ave		1
0254	CENTRAL AVE	16	
0271	NAOMI ST	13	
0285	HOOPER ST	13	
0285_0301	between Hooper St and Washington Switch	1	
0304	LONG BEACH AVE	8	
	Los Angeles Street Running Total	340	15

CAB SIGNAL ROUTE SEGMENT

Loc No.	Location Description	Vehicle	Ped
0390	41ST ST	3	2
0390_0420	between 41st St and Vernon Ave		1
0420	VERNON AVE		15
0426	VERNON STA		4
0450	48TH PL	1	1
0500	55TH ST	3	7
0570	GAGE AVE	2	2
0620	FLORENCE AVE		10
0623	FLORENCE STA		3
0670	NADEAU ST	3	2
0724	FIRESTONE STATION		1
0770	92ND ST		1
0820	CENTURY BLVD	1	4
0840	103RD ST		8
0846	103RD ST STA		1
0880	108TH ST	2	
0930	WILMINGTON AVE	8	4
0940	IMPERIAL HWY	1	3
0946	IMPERIAL PED XING (WEST)		6
0951	IMPERIAL STA		1
0980	119TH ST	1	3
1010	124TH ST	5	1
1040	EL SEGUNDO BLVD		3
1050	130TH ST	2	3
1080	STOCKWELL ST	3	1
1150	ELM ST	2	
1174	COMPTON PED		2
1178	COMPTON STA		3
1190	COMPTON BLVD	1	2
1210	MYRRH ST	1	
1240	ALONDRA BLVD	1	6
1290	GREENLEAF BLVD	6	2
1319	ARTESIA PED		11
1322	ARTESIA STA		2
1350	ARTESIA FWY OVER	1	
1370	MANVILLE ST	1	
1529_1744	between Del Amo and Wardlow Stations		2
1744	WARDLOW STA		1
1750	WARDLOW RD	3	
1750_1810	between Wardlow Rd and Spring St		1
1810	SPRING ST		1
1821	WILLOW NORTH POCKET		1
1843	WILLOW STA		2
	Cab Signal Route Segment Total	51	123

LONG BEACH STREET RUNNING

Loc No.	Location Description	Vehicle	Ped
1847	WILLOW Ped		2
1850	27TH ST	2	
1850_1860	between 27th and Willow St	1	
1860	WILLOW ST	6	
1860_1890	between Willow St and Burnett St	1	
1890	BURNETT ST	14	
1910	HILL ST	16	
1940	20TH ST	22	2
1950	19TH ST	12	
1960	PCH & LB BLVD	3	
1980	16TH ST	8	
2000	14TH ST	18	
2010	ANAHEIM ST	8	
2015	ANAHEIM STA		1
2015_2040	between Anaheim Station and 10th St		1
2040	10TH ST	3	1
2042	9TH ST DIAMOND	1	
2050	8TH ST & LB BLVD	4	
2060	7TH ST & LB BLVD	14	1
2070	6TH ST & LB BLVD	11	
2080	5TH ST PED XING	1	
2090	4TH ST & LB BLVD	3	
2096	3RD ST & LB BLVD	10	
2100	BROADWAY/LB BLVD	8	
2110	1ST ST & LB BLVD	2	
2110_2130	between Long Beach Blvd and Pine Ave	1	
2130	PINE & 1ST ST	2	
2135	TRANSIT MALL STA	1	1
2140	PACIFIC & 1ST ST	5	
2150	BROADWAY & PAC	2	
2155	3RD ST & PACIFIC	8	
2160	4TH ST & PACIFIC	3	
2170	5TH ST & PACIFIC	2	
2180	6TH ST & PACIFIC	7	
2190	7TH ST & PACIFIC	9	
2197	8TH ST & PACIFIC	7	
2200	PINE & 8TH ST	3	
2210	LOCUST & 8TH ST	1	
2215	UNK 8TH STREET	1	
	Long Beach Street Running Total	220	9

TOTAL ACCIDENTS 758

METRO BLUE LINE
TRAIN/VEHICLE AND TRAIN/PEDESTRIAN
ACCIDENTS FROM JULY 1990 THROUGH JUNE 2006

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION: 0062		12TH ST				
7/30/1991	4:45 PM	TA	TS	LT		0
4/9/1992	10:08 AM	TA	TS	LT		0
10/8/1992	10:25 AM	TA	TS	AE		0
9/5/1994	10:09 AM	TA	TS	LT		0
11/8/1994	12:15 PM	TA	TS	LT		0
7/10/1995	4:01 PM	TP	TS	TR		0
10/25/1995	3:04 PM	TA	TS	LT		0
8/7/1996	2:21 PM	TA	TS	LT		0
8/29/1997	11:09 AM	TA	TS	LT/SD	S	0
3/18/1999	2:29 PM	TA	TS	LT/SD	S	0
4/5/2000	9:55 AM	TA	TS	LT/SD	S	0
11/3/2000	2:48 PM	TA	TS	LT/SD	S	0
4/20/2005	5:37 PM	TA	TS	LT/SD	S	0
7/7/2005	10:43 AM	TA	TS	LT/SD	S	0
3/8/2006	5:37 PM	TA	TS	LT/SD	S	0
			No. of accidents:	15	No. of fatalities:	0
LOCATION: 0066		ALLEY NR 12TH ST				
10/7/1997	11:19 AM	TA	S/NLT	LT/SD	S	0
9/4/1998	3:18 PM	TA	S/NLT	LT/SD	S	0
7/28/1999	5:39 PM	TA	S/NLT	LT/SD	S	0
			No. of accidents:	3	No. of fatalities:	0
LOCATION: 0072		PICO STATION PED				
7/30/1990	5:20 PM	TP	S/NLT			0
2/11/2002	4:54 PM	TP	S/NLT		N	0
2/24/2004	7:26 AM	TP	S/NLT	AE	S	0
			No. of accidents:	3	No. of fatalities:	0
LOCATION: 0075		PICO BLVD				
3/15/1991	5:20 PM	TA	TS	LT		0
5/27/1991	11:25 AM	TP	TS			0
11/21/1991	8:06 AM	TA	TS	LT		0
4/20/1992	3:20 PM	TA	TS	RS		0
10/16/1992	9:39 AM	TA	TS	LT/HR		0
7/7/1993	3:27 PM	TA	TS	LT		0

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION: 0075		PICO BLVD				
12/15/1993	4:45 PM	TA	TS	LT		0
7/4/1995	11:47 AM	TA	TS	RS		0
9/19/1996	4:50 PM	TA	TS	LT/HR		0
5/15/1997	1:11 PM	TA	TS	LT/SD	S	0
7/15/1999	11:44 AM	TA	TS	LT/SD	S	0
9/15/1999	7:10 AM	TA	TS	RS/WB	N	0
1/28/2000	12:57 PM	TA	TS	LT/SD/PD	S	0
10/12/2001	2:28 PM	TA	TS	RS/EB	S	0
9/6/2002	12:33 PM	TA	TS	LT/SD/HR	S	0
4/14/2003	4:12 PM	TA	TS	LT/SD	S	0
2/2/2004	10:09 AM	TA	TS	RS/EB	S	0
			No. of accidents:	17	No. of fatalities:	0
LOCATION: 0079		CAMERON LANE				
8/21/1992	3:58 PM	TA	S/NLT	LT		0
9/23/1993	10:12 AM	TA	S/NLT	AE		0
5/16/1994	9:42 AM	TA	S/NLT	AE		0
3/12/1997	11:38 AM	TA	S/NLT	LT/SD/ST	S	0
4/2/1999	5:15 PM	TA	S/NLT	LT/SD	S	0
8/22/1999	9:44 AM	TA	S/NLT	LT/WB	S	0
5/1/2000	4:10 PM	TA	S/NLT	LT/SD	S	0
5/30/2002	2:17 PM	TA	S/NLT	LT/SD	S	0
1/26/2005	7:17 PM	TA	S/NLT	LT/SD	S	0
2/2/2005	5:51 PM	TA	S/NLT	LT/SD/HR	S	0
9/2/2005	11:33 PM	TA	S/NLT		N	0
			No. of accidents:	11	No. of fatalities:	0
LOCATION: 0084		DRIVEWAY AT 1348 FLOWER				
12/7/1995	4:42 PM	TA	S/NLT			0
8/20/2001	4:08 PM	TA	S/NLT	LT/SD	S	
			No. of accidents:	2	No. of fatalities:	0
LOCATION: 0086		DRIVEWAY AT 1360 FLOWER (GLOBE)				
8/21/1992	3:53 PM	TA	S/NLT	AE		0
1/18/1998	4:33 PM	TA	S/NLT	LT/SD	S	0
3/1/2000	11:06 AM	TA	S/NLT	AE	N	0
7/24/2002	5:07 PM	TA	S/NLT	LT/SD	S	0
7/23/2003	1:09 PM	TA	S/NLT	LT/SD	S	0
12/31/2003	9:09 PM	TA	S/NLT	LT/SD	S	0

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION: 0086		DRIVEWAY AT 1360 FLOWER (GLOBE)				
			No. of accidents:	6	No. of fatalities:	0
LOCATION: 0091		DRIVEWAY AT 1370/1374 FLOWER				
1/13/1993	11:18 AM	TA	S/NLT	AE		0
2/5/2000	12:35 PM	TA	S/NLT	LT/SD	S	0
6/23/2000	9:42 AM	TA	S/NLT	LT/SD	S	0
7/18/2000	5:16 PM	TA	S/NLT	LT/SD	S	0
1/12/2004	11:21 AM	TA	S/NLT	LT/SD	S	0
			No. of accidents:	5	No. of fatalities:	0
LOCATION: 0092		DRIVEWAY AT CAL PRESS				
5/10/1993	12:57 PM	TA	S/NLT	AE/HR		0
2/13/1997	6:18 PM	TA	S/NLT	LT/SD	S	0
			No. of accidents:	2	No. of fatalities:	0
LOCATION: 0099		VENICE BLVD				
8/8/1991	6:14 AM	TA	TS	RS		0
3/26/1992	7:57 AM	TA	TS	RS		0
4/12/1992	9:20 PM	TA	TS	LT		0
1/3/1993	9:21 AM	TA	TS	RS		0
5/16/1993	3:05 PM	TA	TS	AE		0
6/16/1993	8:20 AM	TA	TS	LT		0
7/31/1993	7:09 PM	TA	TS	RS/FD		0
2/9/1994	8:50 AM	TA	TS	RS/HR		0
9/6/1994	7:11 AM	TA	TS	RS		0
7/10/1995	9:44 AM	TA	TS	LT		0
10/20/1996	3:41 PM	TA	TS	RS/WB		0
4/8/1997	9:19 AM	TA	TS	RS/WB	N	0
10/25/1997	4:45 PM	TA	TS	RS/EB	S	0
10/7/1998	8:13 AM	TA	TS	RS/EB	N	0
10/17/1998	4:19 PM	TA	TS	RS/EB	S	0
11/28/1998	2:40 PM	TA	TS	HR/EB	N	0
2/18/1999	12:08 PM	TA	TS	LT/SD	S	0
4/11/1999	10:57 AM	TA	TS	RS/WB	S	0
6/6/1999	10:12 AM	TA	TS	RS/EB	N	0
7/12/1999	5:47 PM	TA	TS	LT/SD	S	0
4/21/2000	7:34 AM	TA	TS	WB/AE	N	0
5/28/2000	6:57 AM	TA	TS	EB	N	0
7/28/2000	7:02 AM	TA	TS	LT/SD	S	0

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION: 0099		VENICE BLVD				
9/13/2000	1:42 PM	TA	TS	EB	N	0
12/2/2000	6:25 AM	TA	TS	LT/SD	S	0
1/7/2001	8:13 PM	TA	TS	AE/WB	N	0
4/13/2001	9:41 AM	TA	TS	AE/WB	N	0
1/21/2002	9:40 AM	TA	TS	AE/WB	N	0
3/19/2002	12:33 PM	TA	TS	LT/SD	S	0
7/19/2003	3:03 PM	TA	TS	LT/SD	S	0
4/25/2004	6:59 PM	TA	TS	AE/DR	S	0
7/21/2004	10:21 AM	TA	TS	LT/SD	S	0
1/8/2005	11:44 AM	TA	TS	LT/SD	S	0
8/25/2005	10:34 AM	TA	TS	WB	S	0
1/7/2006	10:44 AM	TA	TS	WB	N	0
3/2/2006	2:26 PM	TA	TS	LT/SD	S	0
			No. of accidents:	36	No. of fatalities:	0
LOCATION: 0104		DRIVEWAY NORTH OF I-10 ON RAMP				
7/21/1993	12:15 PM	TA	S/NLT	LT	S	0
2/28/1994	8:28 AM	TA	S/NLT	RS		0
1/19/1996	10:18 AM	TA	S/NLT	LT		0
3/8/1996	4:50 PM	TA	S/NLT	AE		0
8/18/1999	10:35 AM	TA	S/NLT	LT/SD	S	0
12/6/1999	6:20 PM	TA	S/NLT	LT/SD	S	0
6/30/2004	11:58 AM	TA	S/NLT	LT/SD	S	0
			No. of accidents:	7	No. of fatalities:	0
LOCATION: 0110		I-10 ON RAMP				
3/27/1997	8:24 AM	TA	TS	LT/SD	S	0
5/9/1997	5:52 PM	TA	TS	LT/SD	S	0
5/22/1998	11:58 AM	TA	TS	LT	S	0
9/28/1998	6:35 PM	TA	TS	LT/SD	S	0
9/28/1998	4:09 PM	TA	TS	LT/SD	S	0
2/15/2002	10:58 AM	TA	TS	LT/SD	S	0
			No. of accidents:	6	No. of fatalities:	0
LOCATION: 0112		18TH ST				
1/27/1991	1:50 PM	TA	TS	LT		0
4/5/1993	11:54 AM	TA	TS	LT		0
7/21/1993	1:39 PM	TA	TS	LT		0
10/11/1995	2:13 PM	TA	TS			0

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION: 0112		18TH ST				
4/2/1996	8:19 AM	TA	TS	LT		0
11/5/1996	5:04 PM	TA	TS	LT/HR		0
3/7/1997	8:40 AM	TA	TS	LT/HR/SD	S	0
9/5/1997	5:28 PM	TA	TS	LT/SD	S	0
2/4/1998	4:52 PM	TA	TS	LT/HR	S	0
3/13/2000	6:46 PM	TA	TS	LT	S	0
6/14/2000	1:32 PM	TA	TS	LT/SD	S	0
8/24/2000	3:00 PM	TA	TS	LT/SD	S	0
2/5/2001	3:35 PM	TA	TS	LT/SD	S	
10/17/2001	4:46 PM	TA	TS	LT	S	0
2/18/2002	8:40 AM	TA	TS	LT/SD	S	0
12/16/2003	9:49 PM	TA	TS	LT/SD	S	0
2/17/2005	10:21 AM	TA	TS	LT/SD	S	0
11/21/2005	5:50 PM	TA	TS	LT/SD	S	0
1/8/2006	12:35 PM	TA	TS	LT/SD	S	0
			No. of accidents:	19	No. of fatalities:	0
LOCATION: 0120		UNK FLOWER ST				
6/16/1993	7:40 AM	TA		AE/HR		0
			No. of accidents:	1	No. of fatalities:	0
LOCATION: 0123		WASH BLVD/FLOWER				
12/9/1996	1:40 PM	TA	TS	RS/WB		0
1/21/1997	5:38 PM	TA	TS	AE/HR	N	0
12/13/1997	9:27 PM	TA	TS	RS/HR	N	0
12/18/2003	2:25 PM	TA	TS	WB/RS	N	0
4/27/2005	11:18 PM	TA	TS	WB/RS/DR	N	0
			No. of accidents:	5	No. of fatalities:	0
LOCATION: 0130		HOPE ST				
5/19/1995	3:43 PM	TA		LT		0
			No. of accidents:	1	No. of fatalities:	0
LOCATION: 0140		GRAND AVE				
4/16/1991	7:15 AM	TA	TS	LT		0
4/24/1992	3:10 PM	TA	TS	LT		0
8/24/1992	9:15 PM	TA	TS	LT		0
11/16/1992	12:35 PM	TA	TS	LT/HR		0
3/13/1993	1:38 PM	TA	TS	LT		0
9/1/1993	11:21 AM	TA	TS	LT/HR		0

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION: 0140		GRAND AVE				
11/11/1993	6:53 AM	TP	TS			0
6/3/1994	6:44 PM	TA	TS	LT		0
6/6/1994	6:35 AM	TP	TS			0
3/5/1995	7:18 AM	TA	TS	AE/PD		0
4/13/1995	6:48 AM	TA	TS	LT		0
6/24/1995	10:27 AM	TA	TS	LT		0
1/26/1996	8:10 PM	TA	TS	LT		0
2/15/1996	7:45 AM	TA	TS	LT		0
6/11/1996	6:00 PM	TP	TS			1
10/20/2000	6:38 AM	TA	TS	LT/SD	N	
8/21/2001	4:05 PM	TA	TS	LT/SD	N	0
9/5/2001	9:10 AM	TA	TS	LT/SD	N	0
9/25/2003	6:56 AM	TA	TS	RT/SB/AE	N	0
1/7/2005	12:02 PM	TA	TS	LT/SD	N	0
			No. of accidents:	20	No. of fatalities:	1
LOCATION: 0144		OLIVE ST				
12/28/1992	2:33 PM	TA	TS	LT		0
11/26/1993	1:07 PM	TA	TS	LT/PD		0
11/30/1993	7:18 AM	TA	TS	LT		0
12/6/1993	1:57 PM	TA	TS	LT/HR		0
5/1/1994	6:06 PM	TA	TS	LT/HR		0
9/26/1994	6:20 AM	TA	TS	LT		0
11/3/1994	3:02 PM	TA	TS	LT/HR		0
11/22/1994	9:55 AM	TA	TS	LT		0
12/2/1995	6:44 PM	TA	TS	AE		0
12/14/1998	10:21 AM	TA	TS	LT/SD	N	0
2/1/1999	8:10 AM	TA	TS	LT/HR	S	0
7/8/1999	4:52 PM	TA	TS	LT/SD	N	0
10/22/1999	10:12 AM	TA	TS	LT/SD	S	0
12/21/1999	11:06 AM	TA	TS	LT/SD	S	0
5/26/2000	3:54 AM	TA	TS	LT/SD	S	0
10/24/2002	12:20 PM	TA	TS	LT/SD	N	0
11/22/2002	11:51 PM	TA	TS	LT/SD	S	0
			No. of accidents:	17	No. of fatalities:	0
LOCATION: 0144_0149		between Olive St and Hill St				
3/19/2004	11:51 PM	TA		LT	N	0

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION: 0144_0149		between Olive St and Hill St				
			No. of accidents:	1	No. of fatalities:	0
LOCATION: 0149		HILL ST				
11/12/1991	7:15 AM	TA	TS	AE		0
12/31/1992	8:25 AM	TA	TS	LT		0
1/29/1993	9:46 AM	TA	TS	LT		0
7/30/1993	5:00 PM	TA	TS	AE		0
11/22/1995	4:20 PM	TA	TS	LT/HR		0
12/5/1998	6:12 PM	TA	TS	LT/SD	S	0
6/2/1999	7:04 AM	TA	TS	LT/SD	S	0
6/8/1999	12:23 PM	TA	TS	LT/SD/HR	S	
8/17/2005	3:05 PM	TA	TS	LT/SD	S	0
			No. of accidents:	9	No. of fatalities:	0
LOCATION: 0156		BROADWAY				
1/17/1992	6:48 PM	TA	TS	LT		0
11/28/1992	6:25 AM	TA	TS	LT/HR		0
7/24/1994	12:43 PM	TA	TS	LT		0
10/31/1994	8:57 AM	TA	TS	LT		0
1/7/1995	8:30 AM	TA	TS	LT		0
4/14/1997	4:55 PM	TA	TS	LT/SD/ST	S	0
7/16/1997	6:56 PM	TA	TS	LT/SD	N	0
1/8/1998	1:04 PM	TA	TS	LT/AE	N	0
10/20/1998	11:12 AM	TA	TS	RS/NB	N	0
8/27/1999	3:23 PM	TA	TS	LT/SD	S	0
4/24/2000	6:12 PM	TA	TS	HR	N	0
5/8/2002	10:03 PM	TA	TS	LT/SB/RS	N	0
1/3/2004	8:24 AM	TA	TS	LT/SD	N	0
			No. of accidents:	13	No. of fatalities:	0
LOCATION: 0156_0163		between Broadway and Main St				
12/29/1995	2:42 PM	TA		AE		0
2/24/1998	3:23 PM	TP		TR	N	0
			No. of accidents:	2	No. of fatalities:	0
LOCATION: 0163		MAIN ST				
7/28/1990	1:50 PM	TA	TS	LT		0
9/7/1992	9:55 AM	TA	TS	LT/HR		0
12/15/1992	10:26 AM	TA	TS	AE		0
5/3/1995	8:49 PM	TA	TS	LT		0

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION: 0163		MAIN ST				
10/11/1995	7:30 AM	TA	TS	AE		0
2/10/1997	10:51 PM	TA	TS	LT/SD/PD	S	0
11/12/1997	4:48 PM	TA	TS	LT/SD	S	0
3/28/1998	11:28 AM	TA	TS	LT/SD	N	0
3/28/1998	8:22 AM	TA	TS	LT/SD/HR	N	0
4/9/1999	7:55 PM	TA	TS	LT/SD/HR	N	0
9/18/1999	9:55 AM	TA	TS	LT/SD	N	0
7/6/2000	6:53 PM	TA	TS	LT/SD	N	0
7/30/2000	5:13 PM	TA	TS	LT/SD	N	0
5/1/2001	1:09 PM	TA	TS	LT/SD	N	0
7/30/2002	4:20 PM	TA	TS	RS/NB	S	0
10/18/2002	2:39 PM	TA	TS	LT/SD	N	0
9/14/2004	3:32 PM	TA	TS	LT/SD	N	0
10/25/2005	1:17 PM	TA	TS	LT/SD	N	0
			No. of accidents:	18	No. of fatalities:	0
LOCATION: 0170		LOS ANGELES ST				
7/25/1990	7:11 AM	TA	TS	LT		0
8/27/1990	10:48 AM	TA	TS	LT		0
2/16/1991	9:45 AM	TA	TS	LT		0
2/10/1992	1:08 PM	TA	TS	LT		0
3/13/1992	4:57 PM	TA	TS	LT		0
11/2/1992	5:29 PM	TA	TS	LT/HR		0
2/4/1993	8:01 AM	TA	TS	LT/HR		0
4/16/1994	12:42 PM	TA	TS	AE/HR		0
2/15/1996	9:12 AM	TA	TS	LT		0
7/18/1996	10:37 AM	TA	TS	LT		0
11/3/1996	11:28 AM	TA	TS	AE/HR		0
6/25/1997	1:40 PM	TA	TS	LT/SD	N	
3/23/1998	10:42 AM	TA	TS	LT/SD	N	0
6/29/1998	9:10 AM	TA	TS	LT/SD	S	0
8/4/1998	9:10 AM	TA	TS	LT/SD	S	0
8/25/1998	2:45 PM	TA	TS	LT/SD	N	0
12/7/2000	1:17 PM	TA	TS	LT/SD	N	0
5/14/2003	4:04 PM	TA	TS	LT/SD	S	0
			No. of accidents:	18	No. of fatalities:	0

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION: 0183		MAPLE ST				
7/24/1990	12:00 AM	TA	TS	LT		0
2/4/1991	5:43 PM	TA	TS	LT		0
4/26/1991	8:00 PM	TA	TS	LT		0
10/16/1992	6:50 PM	TA	TS	LT		0
5/2/1994	5:25 PM	TA	TS	AE/PD		0
8/31/1995	3:10 PM	TA	TS			0
9/24/1997	6:20 AM	TA	TS	LT/SD	N	0
10/21/1997	4:53 PM	TA	TS	LT/SD	S	0
3/7/2000	2:44 PM	TA	TS	LT/SD/HR	S	0
1/29/2003	3:37 PM	TA	TS	LT/SD	S	0
5/4/2003	10:49 AM	TA	TS	LT/SD	N	0
7/9/2003	7:18 PM	TA	TS	LT/SD	N	0
7/11/2003	8:53 AM	TA	TS	LT/SD	S	0
9/21/2004	3:04 PM	TA(*)	TS	LT/SD	S	0
10/1/2005	9:30 AM	TA	TS	LT/SD	S	0
			No. of accidents:	15	No. of fatalities:	0
LOCATION: 0190		MAPLE X-OVER				
5/25/2006	6:35 PM	TA(*)		AE	N	0
			No. of accidents:	1	No. of fatalities:	0
LOCATION: 0198		TRINITY ST				
5/12/1991	3:52 PM	TA	TS	LT		0
11/20/1992	4:20 PM	TA	TS	LT		0
1/15/1993	5:17 PM	TA	TS	AE		0
1/26/1993	7:15 PM	TA	TS	LT		0
12/17/1994	1:15 PM	TA	TS	LT		0
6/1/1995	2:26 PM	TA	TS	LT		0
10/6/1995	8:11 PM	TP	TS			0
10/23/1997	8:55 AM	TA	TS	LT/SD	S	0
3/19/1998	6:57 PM	TP	TS	TR	S	1
5/27/1999	10:00 AM	TA	TS	LT/SD	S	0
8/13/1999	4:38 PM	TA	TS	LT/SD	N	1
1/7/2002	2:44 PM	TA	TS	LT/SD	S	0
			No. of accidents:	12	No. of fatalities:	2
LOCATION: 0208		SAN PEDRO ST				
8/19/1990	10:32 AM	TA	TS	LT		0
6/1/1991	2:05 PM	TA	TS	AE		0

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION:	0208	SAN PEDRO ST				
8/26/1991	10:29 AM	TA	TS	AE		0
5/7/1993	12:30 PM	TA	TS	RS		0
8/9/1993	5:10 PM	TA	TS	LT		0
11/5/1993	6:59 PM	TA	TS	LT		0
11/12/1994	12:21 PM	TA	TS	LT		0
11/22/1994	7:27 AM	TA	TS	LT/HR		0
3/2/1995	4:07 PM	TA	TS	LT/HR		0
11/6/1995	9:37 AM	TA	TS	LT		0
12/10/1996	5:15 PM	TA	TS			0
4/27/1997	11:58 AM	TA	TS	LT/SD	S	0
3/12/1998	5:25 PM	TA	TS	LT/SD/HR	S	
2/7/1999	9:29 AM	TA	TS	LT/SD/HR	S	0
12/13/1999	5:36 PM	TA	TS	LT/SD	S	0
7/10/2000	3:40 PM	TA	TS	RS/NB	N	0
9/15/2000	8:43 AM	TA	TS	LT	S	0
8/3/2001	10:50 AM	TA	TS	LT/SD	S	0
10/15/2001	1:49 PM	TA	TS	LT/SD	S	0
10/30/2001	7:56 PM	TA	TS	LT/SD	S	0
12/12/2001	3:33 PM	TA	TS	RS/SB	N	0
5/4/2002	4:49 PM	TA	TS	LT	N	0
3/25/2003	8:02 AM	TA	TS	LT/SD	S	0
5/17/2004	4:04 PM	TA	TS	HR	N	0
5/9/2006	5:43 PM	TA(*)	TS	RS/NB	S	0
			No. of accidents:	25	No. of fatalities:	0
LOCATION:	0215	SAN PEDRO PED				
7/31/1997	7:16 AM	TP	TS		S	0
1/23/1999	1:05 PM	TP	TS		S	0
			No. of accidents:	2	No. of fatalities:	0
LOCATION:	0219	SAN PEDRO STA				
9/6/1990	10:10 PM	TA		AE/DR		0
11/22/2002	7:34 AM	TP			S	1
			No. of accidents:	2	No. of fatalities:	1
LOCATION:	0234	GRIFFITH AVE				
9/1/1990	10:32 AM	TA	TS	LT		0
10/29/1991	1:15 PM	TA	TS	LT		0
8/5/1993	8:23 AM	TA	TS	AE		0

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION: 0234		GRIFFITH AVE				
12/4/1995	10:35 AM	TA	TS	LT/HR		0
1/9/1996	11:01 AM	TA	TS	LT		0
5/27/1997	4:08 PM	TA	TS	LT/SD	S	0
1/26/1999	7:17 PM	TA	TS	LT/SD	S	0
8/5/1999	2:48 PM	TA	TS	RS/UT	S	0
10/16/2001	8:55 AM	TA	TS	LT/SD	N	0
			No. of accidents:	9	No. of fatalities:	0
LOCATION: 0234_0254		between Griffith Ave and Central Ave				
4/22/2001	11:25 AM	TP		WB	N	1
			No. of accidents:	1	No. of fatalities:	1
LOCATION: 0254		CENTRAL AVE				
4/18/1991	4:30 PM	TA	TS	LT		0
10/3/1995	1:22 PM	TA	TS	LT		0
7/8/1996	5:55 PM	TA	TS	LT		0
8/21/1997	9:30 AM	TA	TS	LT/SD	S	0
11/17/1997	7:37 AM	TA	TS	AE/HR	S	0
9/25/1998	8:30 AM	TA	TS	LT/SD	N	0
10/15/1998	8:52 AM	TA	TS	LT/SD	S	0
11/17/1998	9:08 PM	TA	TS	RS/NB	N	0
7/2/1999	5:01 PM	TA	TS	LT/AE	N	0
11/3/1999	6:24 PM	TA	TS	RT/AE/HR	N	0
11/18/1999	6:29 PM	TA	TS	LT/SD	N	0
5/26/2000	5:30 PM	TA	TS	AE/HR	S	0
7/25/2000	12:02 PM	TA	TS	LT/SD	S	0
3/28/2001	9:56 PM	TA	TS	LT/SD/HR	S	0
1/4/2003	7:45 AM	TA	TS	LT/SD	S	0
4/14/2005	4:15 PM	TA	TS	LT/SD	S	0
			No. of accidents:	16	No. of fatalities:	0
LOCATION: 0271		NAOMI ST				
2/2/1991	12:30 PM	TA	TS	LT		0
7/21/1993	8:12 AM	TA	TS	LT/FD		0
1/18/1994	8:10 AM	TA	TS	LT/HR		0
11/6/1996	1:00 PM	TA	TS	LT/HR		0
9/20/1997	1:30 PM	TA	TS	NB/HR	S	0
2/8/1998	9:59 PM	TA	TS	UT/HR	S	0
1/25/1999	8:30 AM	TA	TS	LT/SD	N	0

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION: 0271		NAOMI ST				
4/8/1999	1:05 PM	TA	TS	LT/HR	S	0
9/30/1999	1:38 PM	TA	TS	LT/SD	S	
10/1/2001	6:09 AM	TA	TS	LT/SD	S	0
6/2/2002	10:17 AM	TA	TS	LT/SD	S	0
9/15/2004	1:29 PM	TA	TS	LT/SD	S	0
3/13/2006	9:34 AM	TA	TS	LT/SD	S	0
			No. of accidents:	13	No. of fatalities:	0
LOCATION: 0285		HOOPER ST				
10/8/1990	2:23 PM	TA	TS	LT		0
5/7/1993	12:03 PM	TA	TS	LT		0
6/23/1993	1:20 PM	TA	TS	LT		0
3/6/1998	5:50 PM	TA	TS	LT/SD	N	0
6/12/1998	1:27 PM	TA	TS	LT/SD/AE	S	0
2/3/1999	10:15 AM	TA	TS	LT/SD	S	0
3/2/1999	3:58 PM	TA	TS	LT/HR	S	0
3/22/1999	12:27 PM	TA	TS	LT/SD	S	0
5/3/1999	2:54 PM	TA	TS		N	0
7/14/1999	8:30 AM	TA	TS	AE/HR	N	0
8/3/2000	11:38 AM	TA	TS	LT/SD	N	0
1/16/2002	3:47 PM	TA	TS	LT/SD/AE	N	0
5/12/2006	6:12 PM	TA(*)	TS	RS/SB	S	0
			No. of accidents:	13	No. of fatalities:	0
LOCATION: 0285_0301		between Hooper St & Switch to Washington				
3/21/2004	8:27 PM	TA		AE	N	0
			No. of accidents:	1	No. of fatalities:	0
LOCATION: 0304		LONG BEACH AVE				
8/20/1991	8:50 AM	TA	TS	AE		0
7/31/1992	10:31 PM	TA	TS	AE		0
6/1/1993	9:01 AM	TA	TS	AE		0
4/10/1994	4:25 PM	TA	TS	AE/HR		0
11/19/1995	3:39 PM	TA	TS	AE		0
5/13/1999	10:59 PM	TA	TS	HR		0
8/4/2002	9:02 AM	TA	TS	RS/HR	S	0
9/27/2005	8:45 AM	TA	TS	AE/HR	S	0
			No. of accidents:	8	No. of fatalities:	0

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION: 0390		41ST ST				
10/24/1990	4:36 PM	TA	GFLB/TS	RG/ST		2
12/30/1991	1:22 PM	TA	GFLB/TS	RG		1
5/22/1993	6:38 AM	TA	GFLB/TS	RG/SU		1
6/7/2004	4:40 PM	TP	GFLB/TS	EB	S	0
11/23/2005	5:47 PM	TP	GFLB/TS	RG/FLB/WB	S	0
			No. of accidents:	5	No. of fatalities:	4
LOCATION: 0390_0420		between 41st St & Vernon Ave				
12/10/2003	12:59 AM	TP		SU	S	1
			No. of accidents:	1	No. of fatalities:	1
LOCATION: 0420		VERNON AVE				
11/7/1990	8:05 PM	TP	GFLB/TS			1
3/15/1992	6:22 AM	TP	GFLB/TS			0
5/11/1992	12:59 PM	TP	GFLB/TS			0
10/9/1992	4:13 PM	TP	GFLB/TS			0
4/12/1993	3:58 PM	TP	GFLB/TS			0
8/15/1993	8:18 PM	TP	GFLB/TS	SU		1
10/8/1993	3:31 PM	TP	GFLB/TS			0
11/25/1994	5:51 PM	TP	GFLB/TS			1
4/6/1996	7:58 PM	TP	GFLB/TS			0
5/19/1997	4:40 PM	TP	GFLB/TS		S	0
5/7/1998	10:30 AM	TP	GFLB/TS	TR/EB	S	1
6/13/2000	7:22 PM	TP	GFLB/TS	DR	S	0
8/7/2000	1:57 PM	TP	GFLB/TS		S	0
11/2/2000	2:29 PM	TP	GFLB/TS		S	
7/19/2001	5:09 PM	TP	GFLB/TS	EB	S	1
			No. of accidents:	15	No. of fatalities:	5
LOCATION: 0426		VERNON STA				
8/23/1999	7:29 AM	TP			S	0
11/11/1999	3:05 PM	TP			S	0
12/22/2001	2:53 PM	TP			S	0
7/22/2005	5:26 PM	TP		FLB/WB	S	0
			No. of accidents:	4	No. of fatalities:	0
LOCATION: 0450		48TH PL				
4/24/2002	11:39 AM	TA	GFLB/TS	AE	N	0
2/4/2005	7:46 AM	TP	GFLB/TS	SU	S	0
			No. of accidents:	2	No. of fatalities:	0

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION: 0500		55TH ST				
10/16/1990	4:16 PM	TA	GFLB	RG/ST		0
10/26/1991	10:06 PM	TP	GFLB	TR		0
5/1/1992	9:23 AM	TP	GFLB			0
8/20/1992	8:30 PM	TP	GFLB			0
9/12/1992	3:20 PM	TA	GFLB	RG/ST		1
6/10/1993	5:33 AM	TP	GFLB			1
2/27/1994	12:20 PM	TP	GFLB			1
5/2/1996	12:47 PM	TA	GFLB	RG/EB		0
7/16/1999	4:27 PM	TP	GFLB	SU	S	1
3/17/2006	5:32 PM	TP	GFLB	RG/WB	S	1
			No. of accidents:	10	No. of fatalities:	5
LOCATION: 0570		GAGE AVE				
2/12/1992	10:55 AM	TA	GFLB	RG		0
5/26/1992	6:20 AM	TA	GFLB	RG		0
8/28/2005	5:45 PM	TP	GFLB		N	0
6/6/2006	11:31 AM	TP(*)	GFLB	WB	N	1
			No. of accidents:	4	No. of fatalities:	1
LOCATION: 0620		FLORENCE AVE				
9/8/1990	12:10 PM	TP	GFLB			0
2/18/1992	12:25 PM	TP	GFLB			0
7/23/1997	4:54 PM	TP	GFLB	WB	S	1
11/24/1997	1:35 PM	TP	GFLB	EB	S	0
12/13/1997	5:24 PM	TP	GFLB		S	0
2/27/1998	7:50 AM	TP	GFLB	TR	S	1
6/28/1999	6:05 AM	TP	GFLB		N	0
4/9/2001	4:24 PM	TP	GFLB		S	0
9/1/2004	4:31 PM	TP	GFLB	EB	S	1
11/25/2004	2:58 PM	TP	GFLB	SU	S	1
			No. of accidents:	10	No. of fatalities:	4
LOCATION: 0623		FLORENCE STA				
12/5/1997	5:28 PM	TP			N	0
6/10/1998	4:30 PM	TP			S	0
10/3/2005	6:55 PM	TP			N	0
			No. of accidents:	3	No. of fatalities:	0
LOCATION: 0670		NADEAU ST				
8/10/205	9:50 AM	TP	GFLB	FLB/EB	S	0

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION: 0670		NADEAU ST				
7/17/1990	6:07 PM	TA	GFLB	RG		0
4/11/1996	9:03 PM	TA	GFLB	RG/EB	N	0
2/22/1997	1:38 PM	TP	GFLB		S	0
7/21/2003	2:07 PM	TA	GFLB	AE	N	0
			No. of accidents:	5	No. of fatalities:	0
LOCATION: 0724		FIRESTONE STA				
4/15/2003	2:03 AM	TP		DR	N	0
			No. of accidents:	1	No. of fatalities:	0
LOCATION: 0770		92ND ST				
4/8/2002	7:27 PM	TP	GFLB		S	0
			No. of accidents:	1	No. of fatalities:	0
LOCATION: 0820		CENTURY BLVD				
9/20/1990	5:29 PM	TP	DGFLB/TS			1
1/8/1995	11:29 AM	TP	DGFLB/TS			1
5/29/1999	4:03 PM	TA	DGFLB/TS	RG/RT/HR	N	0
2/12/2003	8:39 PM	TP	DGFLB/TS	FLB/EB	N	1
3/31/2003	3:52 PM	TP	DGFLB/TS	EB	S	0
			No. of accidents:	5	No. of fatalities:	3
LOCATION: 0840		103RD ST				
5/20/1991	11:32 AM	TP	GFLB/TS	ST		0
10/6/1996	1:39 PM	TP	GFLB/TS			0
2/17/1997	9:41 PM	TP	GFLB/TS		S	0
2/26/1997	6:21 AM	TP	GFLB/TS	EB	S	0
10/31/1997	3:48 PM	TP	GFLB/TS		N	0
2/21/1998	12:51 PM	TP	GFLB/TS	TR/SU	S	1
10/16/1998	3:28 PM	TP	GFLB/TS		N	0
6/24/1999	1:49 PM	TP	GFLB/TS		S	1
			No. of accidents:	8	No. of fatalities:	2
LOCATION: 0846		103RD ST STA				
6/23/1997	9:27 AM	TP			N	0
			No. of accidents:	1	No. of fatalities:	0
LOCATION: 0880		108TH ST				
12/12/1992	11:25 AM	TA	GFLB/S	RG/EB		0
6/28/1994	2:35 PM	TA	GFLB/S	RG		0
			No. of accidents:	2	No. of fatalities:	0

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION: 0930		WILMINGTON AVE				
9/25/1992	6:56 PM	TA	GFLB	RG		0
6/19/1994	6:27 PM	TP	GFLB			0
12/20/1994	8:47 AM	TA	GFLB	RG		0
11/20/1995	9:30 PM	TA	GFLB	RG/HR		0
5/6/1998	10:29 PM	TA	GFLB	RG	S	1
5/16/1998	8:50 PM	TP	GFLB	TR/WB	S	1
7/7/1998	7:54 AM	TP	GFLB	TR/EB	S	1
11/25/1998	9:08 PM	TP	GFLB	TR	S	1
12/22/1999	11:17 AM	TA	GFLB	LT/SD/RG	S	0
12/11/2003	8:44 AM	TA	GFLB	AE	S	0
3/1/2004	8:00 AM	TA	GFLB	LT/RG	S	2
5/5/2006	8:16 AM	TA(*)	GFLB		N	0
			No. of accidents:	12	No. of fatalities:	6
LOCATION: 0940		IMPERIAL HWY				
10/8/1994	2:00 PM	TP	GFLB/TS			1
9/2/1996	12:46 PM	TA	GFLB/TS	RG/LT		0
3/27/1997	5:12 PM	TP	GFLB/TS	EB	S	1
8/30/1999	4:20 PM	TP	GFLB/TS		S	0
			No. of accidents:	4	No. of fatalities:	2
LOCATION: 0946		IMPERIAL PED XING (WEST)				
11/28/1994	4:05 PM	TP	FLB			0
12/14/1998	3:53 PM	TP	FLB		S	1
9/1/1999	2:39 PM	TP	FLB	EB	S	0
11/5/2001	12:41 PM	TP	FLB		S	1
7/2/2003	8:56 AM	TP	FLB	EB	S	0
5/8/2004	1:04 PM	TP	FLB	FLB/EB	S	1
			No. of accidents:	6	No. of fatalities:	3
LOCATION: 0951		IMPERIAL STA				
6/1/1995	4:00 PM	TP				0
			No. of accidents:	1	No. of fatalities:	0
LOCATION: 0980		119TH ST				
1/23/1998	4:20 PM	TA	GFLB/TS	RG/WB	S	0
6/17/2001	10:55 PM	TP	GFLB/TS	DR	N	0
1/8/2003	4:43 PM	TP	GFLB/TS	FLB/WB	N	0
3/4/2004	5:10 PM	TP	GFLB/TS	RG/SU	N	1
			No. of accidents:	4	No. of fatalities:	1

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION: 1010		124TH ST				
3/4/1992	10:44 PM	TA	GFLB/TS	RG		0
11/16/1993	9:00 PM	TA	GFLB/TS	RG/ST		2
4/5/1995	5:23 PM	TA	GFLB/TS	RG		0
5/3/1995	8:49 PM	TP	GFLB/TS	TR		1
9/1/1996	4:02 PM	TA	GFLB/TS	RG		0
6/14/2003	11:50 PM	TA	GFLB/TS	RG/SU	S&N	0
			No. of accidents:	6	No. of fatalities:	3
LOCATION: 1040		EL SEGUNDO BLVD				
7/26/1994	9:07 AM	TP	DGFLB/TS			1
10/15/1998	4:38 PM	TP	DGFLB/TS		N	1
1/7/2006	7:02 PM	TP	DGFLB/TS		N	0
			No. of accidents:	3	No. of fatalities:	2
LOCATION: 1050		130TH ST				
6/29/1991	12:05 PM	TP	GFLB/TS	SU		1
12/31/1991	4:49 PM	TA	GFLB/TS	RG/EB		0
11/20/1992	7:44 PM	TA	GFLB/TS	RG/DR		0
11/13/1993	3:20 PM	TP	GFLB/TS			1
12/23/1996	8:45 AM	TP	GFLB/TS			1
			No. of accidents:	5	No. of fatalities:	3
LOCATION: 1080		STOCKWELL ST				
5/18/1993	7:30 PM	TA	GFLB/TS	RG/ST		2
4/13/2002	7:12 PM	TA	GFLB/TS	AE	S	0
12/9/2003	5:08 PM	TP	GFLB/TS	EB/FLB/ST	N	1
12/2/2004	6:35 AM	TA	GFLB/TS	LT/SD	N	1
			No. of accidents:	4	No. of fatalities:	4
LOCATION: 1150		ELM ST				
10/4/1990	5:34 AM	TA	GFLB	RG/ST		0
6/24/1996	7:28 AM	TA	GFLB	RG/LT		0
			No. of accidents:	2	No. of fatalities:	0
LOCATION: 1174		COMPTON PED				
11/7/1996	5:55 PM	TP	FLB			0
4/3/2004	11:21 AM	TP	FLB		N	0
			No. of accidents:	2	No. of fatalities:	0
LOCATION: 1178		COMPTON STA				
11/13/1992	6:32 AM	TP				0
3/25/2000	9:54 PM	TP			S	0

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION: 1178		COMPTON STA				
7/18/2002	4:18 PM	TP		WB	N	0
			No. of accidents:	3	No. of fatalities:	0
LOCATION: 1190		COMPTON BLVD				
5/10/1996	11:03 AM	TP	DGFLB/TS			0
12/10/1997	4:00 PM	TA	DGFLB/TS	RG/ST	N	0
3/27/2000	3:54 PM	TP	DGFLB/TS	TR/SU	N	0
			No. of accidents:	3	No. of fatalities:	0
LOCATION: 1210		MYRRH ST				
3/19/1991	1:40 PM	TA	GFLB/TS	RG		0
			No. of accidents:	1	No. of fatalities:	0
LOCATION: 1240		ALONDRA BLVD				
1/15/1991	11:43 AM	TA	GFLB/TS	RG		0
2/19/1995	4:08 PM	TP	GFLB/TS			1
7/24/1999	7:09 AM	TP	GFLB/TS	TR/SU	S	1
3/13/2001	6:11 AM	TP	GFLB/TS	WB/SU	N	1
7/31/2001	4:32 PM	TP	GFLB/TS		N	0
7/11/2005	6:33 PM	TP	GFLB/TS	EB	S	1
9/13/2005	8:07 PM	TP	GFLB/TS	TR/SU	N	1
			No. of accidents:	7	No. of fatalities:	5
LOCATION: 1290		GREENLEAF BLVD				
8/7/1990	11:15 AM	TA	GFLB/S	RG/ST		0
4/25/1993	8:40 PM	TA	GFLB/S	RG		0
11/29/1993	9:39 AM	TP	GFLB/S	SU		1
11/28/1994	8:44 PM	TA	GFLB/S	RG/HR		0
4/10/1995	8:29 PM	TA	GFLB/S	RG		0
9/18/1995	3:00 PM	TA	GFLB/S	RG		0
11/27/1999	11:02 PM	TA	GFLB/S	LT/SD/RG	S	6
5/27/2004	12:53 PM	TP	GFLB/S	FLB/WB	N	1
			No. of accidents:	8	No. of fatalities:	8
LOCATION: 1319		ARTESIA PED				
8/13/1991	7:55 AM	TP	FLB	ST		0
3/18/1992	4:55 PM	TP	FLB	ST		0
6/17/1992	9:18 AM	TP	FLB		S	0
12/16/1994	9:01 AM	TP	FLB			0
6/12/1998	8:15 AM	TP	FLB		S	0
10/22/2001	5:12 PM	TP	FLB		S	0

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION:	1319	ARTESIA PED				
6/24/2002	10:10 AM	TP	FLB	SU	S	1
11/9/2002	5:50 AM	TP	FLB		S	0
12/23/2002	12:33 PM	TP	FLB	FLB	S	0
9/21/2004	11:33 AM	TP	FLB	EB	S	0
4/4/2006	12:58 PM	TP(*)	FLB		S	1
			No. of accidents:	11	No. of fatalities:	2
LOCATION:	1322	ARTESIA STA				
7/7/2001	8:23 PM	TP		DR	S	0
10/27/2001	3:38 PM	TP			S	0
			No. of accidents:	2	No. of fatalities:	0
LOCATION:	1350	ARTESIA FWY OVER				
1/8/1994	5:22 AM	TA		AE		0
			No. of accidents:	1	No. of fatalities:	0
LOCATION:	1370	MANVILLE ST				
1/18/1992	3:32 PM	TA	GFLB/S	RG/EB		1
			No. of accidents:	1	No. of fatalities:	1
LOCATION:	1529_1744	between Del Amo and Wardlow Stations				
10/30/2000	1:05 AM	TP			N	0
7/8/2001	10:21 PM	TP		TR	N	1
			No. of accidents:	2	No. of fatalities:	1
LOCATION:	1744	WARDLOW STA				
2/26/2000	5:47 PM	TP			N	0
			No. of accidents:	1	No. of fatalities:	0
LOCATION:	1750	WARDLOW RD				
6/2/1992	8:13 AM	TA	GFLB/TS	RG		0
3/14/2000	6:30 PM	TA	GFLB/TS	WB	N	0
11/23/2002	6:28 AM	TA	GFLB/TS	WB/RG	S	0
			No. of accidents:	3	No. of fatalities:	0
LOCATION:	1750_1810	between Wardlow Rd and Spring St				
4/30/2004	1:38 AM	TP		TR/SU	N	1
			No. of accidents:	1	No. of fatalities:	1
LOCATION:	1810	SPRING ST				
8/19/1995	7:21 PM	TP	GFLB	TR/SU		1
			No. of accidents:	1	No. of fatalities:	1

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION: 1821		WILLOW N POCKET				
5/1/2005	12:24 AM	TP		SU	S	0
			No. of accidents:	1	No. of fatalities:	0
LOCATION: 1843		WILLOW STA				
11/13/1997	6:03 PM	TP			N	0
6/1/2005	5:38 PM	TP		WB	N	0
			No. of accidents:	2	No. of fatalities:	0
LOCATION: 1847		WILLOW PED				
12/22/2002	8:55 PM	TP	W/DW		N	0
3/4/2003	1:59 PM	TP	W/DW	SB	N	
			No. of accidents:	2	No. of fatalities:	0
LOCATION: 1850		27TH ST				
1/4/2001	5:01 PM	TA	TS		S	0
10/8/2001	5:13 PM	TA	TS		S	0
			No. of accidents:	2	No. of fatalities:	0
LOCATION: 1850_1860		between 27th and Willow St				
5/24/1999	12:00 PM	TA		LT/AE	S	0
			No. of accidents:	1	No. of fatalities:	0
LOCATION: 1860		WILLOW ST				
3/8/1991	6:41 PM	TA	TS	UT/PD		0
6/30/1991	10:08 PM	TA	TS	LT		0
10/1/1991	5:30 PM	TA	TS	AE		0
3/11/1995	11:36 PM	TA	TS	LT/HR		0
12/11/2001	4:18 PM	TA	TS	AE	N	0
11/5/2002	5:06 PM	TA	TS	LT/SD/HR	S	0
			No. of accidents:	6	No. of fatalities:	0
LOCATION: 1860_1890		between Willow St & Burnett St				
1/29/2004	5:51 PM	TA		AE/HR	N	0
			No. of accidents:	1	No. of fatalities:	0
LOCATION: 1890		BURNETT ST				
10/25/1990	8:05 AM	TA	TS	LT		0
4/26/1991	12:15 PM	TA	TS	LT		0
7/12/1991	5:15 PM	TA	TS	AE		0
7/26/1991	8:35 AM	TA	TS	AE		0
9/26/1991	4:35 PM	TA	TS	LT		0
6/9/1992	7:33 PM	TA	TS	LT		0
9/25/1993	6:55 PM	TA	TS	LT		0

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION: 1890		BURNETT ST				
7/9/1994	1:24 PM	TA	TS	LT/HR		0
8/24/1995	2:46 PM	TA	TS	LT		0
1/28/1997	7:00 PM	TA	TS	LT/SD	S	0
8/16/2000	5:48 PM	TA	TS	LT/SD/AE	S	0
1/27/2001	10:53 AM	TA	TS	LT/SD	N	0
6/25/2002	12:34 PM	TA	TS	LT/SD	S	0
1/17/2004	9:09 PM	TA	TS	LT/SD	S	0
			No. of accidents:	14	No. of fatalities:	0
LOCATION: 1910		HILL ST				
10/25/1990	7:40 PM	TA	TS	LT		0
1/22/1991	5:56 PM	TA	TS	LT		0
3/25/1991	2:25 PM	TA	TS	LT		0
7/9/1993	10:58 PM	TA	TS	LT		0
1/19/1994	7:16 PM	TA	TS	LT		0
12/2/1996	9:15 PM	TA	TS	AE/HR		0
1/19/1997	8:11 PM	TA	TS	LT/SD	N	
2/28/1997	10:38 PM	TA	TS	LT/SD/HR	N	0
6/14/1999	8:23 AM	TA	TS	LT/SD	S	0
8/7/1999	9:43 PM	TA	TS	LT/SD	N	0
1/15/2000	7:04 AM	TA	TS	LT/SD/HR	N	0
3/26/2000	6:34 PM	TA	TS	LT/SD	S	0
12/24/2000	9:04 AM	TA	TS	LT/SD	S	0
1/15/2001	1:39 PM	TA	TS	LT/SD	S	0
10/24/2001	7:11 PM	TA	TS	LT/SD	N	0
6/20/2002	9:03 AM	TA	TS	LT/SD	S	0
			No. of accidents:	16	No. of fatalities:	0
LOCATION: 1940		20TH ST				
12/16/1990	7:30 AM	TA	TS	LT		0
3/14/1991	2:09 PM	TA	TS	LT		0
7/3/1991	5:21 PM	TA	TS	LT		0
2/5/1992	4:26 PM	TP	TS			0
8/11/1992	1:39 PM	TA	TS	LT		0
8/30/1992	1:03 PM	TA	TS	LT		0
9/11/1992	8:46 AM	TA	TS	LT		0
11/20/1992	5:20 PM	TA	TS	AE/HR		0
7/20/1993	10:15 PM	TP	TS			1

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION: 1940		20TH ST				
11/7/1993	9:17 PM	TA	TS	LT/HR		0
1/19/1994	4:11 PM	TA	TS	AE		0
1/31/1994	12:39 PM	TA	TS	LT		0
5/6/1994	5:08 PM	TA	TS	LT		0
7/19/1994	11:04 PM	TA	TS	AE		0
5/5/1995	9:59 PM	TA	TS	LT		0
10/19/1995	9:08 AM	TA	TS	LT		0
3/12/1999	12:48 PM	TA	TS	LT/SD	S	0
10/16/1999	6:18 PM	TA	TS	LT/SD	S	0
11/15/1999	5:47 PM	TA	TS	LT/SD	S	
6/6/2000	8:06 AM	TA	TS	LT/SD/HR	S	0
1/9/2001	9:04 AM	TA	TS	LT/SD	N	0
8/6/2001	1:01 PM	TA	TS	LT/SD	N	0
2/27/2004	1:51 PM	TA	TS	LT/SD	N	0
10/25/2005	4:29 PM	TA	TS	LT/SD	N	0
			No. of accidents:	24	No. of fatalities:	1
LOCATION: 1950		19TH ST				
2/8/1991	5:51 PM	TA	TS	LT		0
3/14/1991	12:45 PM	TA	TS	LT		0
4/4/1991	1:05 PM	TA	TS	LT		0
4/8/1991	8:13 AM	TA	TS	LT		0
5/10/1991	8:15 AM	TA	TS	LT		0
10/2/1992	8:57 PM	TA	TS	LT		0
12/30/1996	5:58 PM	TA	TS	LT		0
12/17/2000	11:50 AM	TA	TS	LT/SD	S	0
4/10/2002	5:44 PM	TA	TS	LT/SD	S	0
9/14/2003	12:17 PM	TA	TS	LT/SD	N	0
7/29/2004	9:52 AM	TA	TS	LT/SD	N	0
5/3/2005	8:11 AM	TA	TS	LT/SD	N	0
			No. of accidents:	12	No. of fatalities:	0
LOCATION: 1960		PCH & LB BLVD				
9/13/1993	8:53 AM	TA	TS	LT/HR		0
3/23/1996	1:27 PM	TA	TS	AE/HR		0
11/20/2005	12:49 PM	TA	TS	LT/SD/HR	S	0
			No. of accidents:	3	No. of fatalities:	0

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION: 1980		16TH ST				
9/14/1990	3:15 PM	TA	TS	LT		0
1/8/1992	5:24 AM	TA	TS	LT		0
4/6/1996	5:00 PM	TA	TS	LT		0
5/7/1999	11:02 AM	TA	TS	LT/SD/HR	S	0
6/4/1999	5:28 PM	TA	TS	LT/SD	N	0
2/17/2000	9:49 AM	TA	TS	LT/SD	N	0
1/15/2001	12:51 PM	TA	TS	LT/SD	S	0
11/14/2002	6:56 PM	TA	TS	LT/SD/HR	N	0
			No. of accidents:	8	No. of fatalities:	0
LOCATION: 2000		14TH ST				
12/1/1990	3:30 PM	TA	TS	UT/DR		0
1/26/1991	12:00 AM	TA	TS	UT		0
1/30/1991	4:50 PM	TA	TS	UT		0
1/9/1992	10:23 PM	TA	TS	LT		0
9/25/1992	10:48 AM	TA	TS	LT		0
10/18/1992	6:24 PM	TA	TS	LT		0
2/7/1993	11:08 AM	TA	TS	LT/HR		0
2/25/1993	4:25 PM	TA	TS	LT/HR		0
7/17/1993	9:08 PM	TA	TS	LT		0
9/15/2000	2:23 PM	TA	TS	LT/SD	S	0
2/26/2001	5:23 PM	TA	TS	LT/SD	N	0
7/5/2001	9:26 AM	TA	TS	LT/SD	S	0
8/19/2002	11:41 PM	TA	TS	LT/SD	S	0
2/4/2003	7:33 AM	TA	TS	LT/SD	S	0
2/6/2004	7:54 AM	TA	TS	LT/SD	N	0
2/8/2004	3:00 PM	TA	TS	LT/SD	N	0
7/16/2004	11:52 AM	TA	TS	LT/SD	N	0
10/15/2004	4:24 PM	TA	TS	LT/SD	S	0
			No. of accidents:	18	No. of fatalities:	0
LOCATION: 2010		ANAHEIM ST				
10/22/1991	6:23 PM	TA	TS	LT		0
3/26/1992	3:07 PM	TA	TS	LT		0
12/14/1992	8:46 AM	TA	TS	LT		0
1/8/1998	8:46 AM	TA	TS	LT/SD	S	0
6/9/1998	5:41 AM	TA	TS	LT/SD	N	0
3/16/2001	7:37 AM	TA	TS	LT/SD/AE	S	0

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION: 2010		ANAHEIM ST				
9/7/2001	8:45 AM	TA	TS	LT/SD	S	0
10/10/2001	5:57 PM	TA	TS	AE	N	0
			No. of accidents:	8	No. of fatalities:	0
LOCATION: 2015		ANAHEIM STA				
10/28/2000	11:59 AM	TP			N	0
			No. of accidents:	1	No. of fatalities:	0
LOCATION: 2015_2040		between Anaheim Station and 10th St				
6/26/2000	2:51 PM	TP		WB	N	1
			No. of accidents:	1	No. of fatalities:	1
LOCATION: 2040		10TH ST				
12/3/1990	11:17 AM	TA	TS	LT		0
9/23/1992	8:28 PM	TA	TS	LT		0
9/7/2004	11:08 PM	TP	TS	EB/SU	N	1
7/14/2005	11:21 AM	TA	TS	LT/SD	N	0
			No. of accidents:	4	No. of fatalities:	1
LOCATION: 2042		9TH ST DIAMOND				
9/1/1992	10:08 PM	TA		AE/HR		0
			No. of accidents:	1	No. of fatalities:	0
LOCATION: 2050		8TH ST & LB BLVD				
1/20/1993	11:57 AM	TA	TS	LT		0
4/4/1999	6:27 PM	TA	TS	RS/SB	N	0
1/26/2004	12:41 PM	TA	TS	LT/SD/HR	S	0
8/4/2004	12:27 PM	TA	TS	LT/SD	S	0
			No. of accidents:	4	No. of fatalities:	0
LOCATION: 2060		7TH ST & LB BLVD				
1/7/1991	6:55 PM	TA	TS	LT		0
1/29/1992	3:18 PM	TA	TS	LT		0
1/26/1993	8:34 AM	TA	TS	AE		0
6/21/1997	3:34 PM	TP	TS	WB	S	0
6/28/1999	11:02 AM	TA	TS	LT/SD	S	0
12/26/1999	5:55 PM	TA	TS	LT/SD	S	0
3/1/2000	9:54 PM	TA	TS	LT/SD	S	0
4/2/2001	12:14 PM	TA	TS	LT/SD	S	0
5/23/2001	12:17 PM	TA	TS	LT/SD	S	0
1/9/2002	5:08 PM	TA	TS	LT/SD	S	0
7/7/2002	8:37 AM	TA	TS	LT/SD	S	0

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION: 2060		7TH ST & LB BLVD				
11/24/2002	4:43 PM	TA	TS	LT/SD	S	0
5/3/2003	10:45 AM	TA	TS	LT/SD	S	0
5/8/2003	9:27 AM	TA	TS	LT/SD	S	0
2/20/2004	6:21 PM	TA	TS	LT/SD	S	0
			No. of accidents:	15	No. of fatalities:	0
LOCATION: 2070		6TH ST & LB BLVD				
4/9/1991	7:12 PM	TA	TS	LT		0
1/19/1993	12:43 PM	TA	TS	LT		0
4/5/1993	10:49 AM	TA	TS	LT		0
9/12/1995	3:07 PM	TA	TS	LT		0
9/6/1999	12:57 PM	TA	TS	LT/SD	S	0
9/29/1999	5:55 PM	TA	TS	LT/SD	S	0
12/26/1999	8:21 AM	TA	TS	LT/SD	S	0
1/20/2000	1:43 PM	TA	TS	LT	S	0
2/27/2000	9:49 AM	TA	TS	LT/SD	S	0
2/23/2001	6:58 PM	TA	TS	HR	S	0
6/3/2006	1:31 PM	TA(*)	TS	LT/SD	S	0
			No. of accidents:	11	No. of fatalities:	0
LOCATION: 2080		5TH ST PED XING				
12/8/2000	2:20 PM	TA	TS	LT	S	0
			No. of accidents:	1	No. of fatalities:	0
LOCATION: 2090		4TH ST & LB BLVD				
10/31/1990	4:18 PM	TA	TS	LT		0
11/8/1990	9:30 AM	TA	TS	LT		0
4/15/1995	5:33 PM	TA	TS	LT		0
			No. of accidents:	3	No. of fatalities:	0
LOCATION: 2096		3RD ST & LB BLVD				
9/19/1990	1:37 PM	TA	TS	LT		0
5/27/1991	2:50 PM	TA	TS	UT		0
8/23/1991	5:11 PM	TA	TS	UT		0
10/22/1991	6:45 PM	TA	TS	RS		0
7/15/1992	9:55 PM	TA	TS	LT		0
1/17/1999	2:10 PM	TA	TS	LT	S	0
3/21/1999	9:55 AM	TA	TS		S	0
10/23/1999	4:55 PM	TA	TS	LT/SD	S	0
4/30/2001	1:45 PM	TA	TS	LT/EB/HR	S	0

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION: 2096		3RD ST & LB BLVD				
6/16/2001	7:11 PM	TA	TS	LT/SD	S	0
			No. of accidents:	10	No. of fatalities:	0
LOCATION: 2100		BROADWAY/LB BLVD				
6/17/1991	9:04 PM	TA	TS	LT		0
9/7/1991	2:12 PM	TA	TS	UT		0
7/19/1993	7:06 PM	TA	TS	LT		0
2/3/1997	5:22 PM	TA	TS	LT/SD	S	0
4/18/1997	8:46 AM	TA	TS	LT/SD	S	0
2/16/1998	3:48 PM	TA	TS	LT/SD	S	0
8/19/2001	2:55 PM	TA	TS	LT/SD	S	0
9/10/2003	6:10 PM	TA	TS	LT/SD	S	0
			No. of accidents:	8	No. of fatalities:	0
LOCATION: 2110		1ST ST & LB BLVD				
6/24/1999	4:25 PM	TA	TS	RT	N	0
6/27/2005	5:02 PM	TA	TS	RT	N	0
			No. of accidents:	2	No. of fatalities:	0
LOCATION: 2110_2130		between Long Beach Blvd and Pine Ave				
10/18/1998	11:59 PM	TA		AE	S	0
			No. of accidents:	1	No. of fatalities:	0
LOCATION: 2130		PINE & 1ST ST				
2/23/2001	2:51 PM	TA	TS	AE	S	0
7/19/2003	1:50 AM	TA	TS	LT/SD/HR	S	0
			No. of accidents:	2	No. of fatalities:	0
LOCATION: 2135		TRANSIT MALL STA				
8/16/1991	3:41 PM	TP				0
12/17/1992	6:39 PM	TA		AE		2
			No. of accidents:	2	No. of fatalities:	2
LOCATION: 2140		PACIFIC & 1ST ST				
8/30/1990	3:15 PM	TA	TS	RT		0
8/8/1992	11:30 AM	TA	TS	LT/HR		0
10/6/1993	5:55 PM	TA	TS	AE		0
3/17/1997	5:16 PM	TA	TS	AE	N	0
1/26/1998	3:34 PM	TA	TS	AE	N	0
			No. of accidents:	5	No. of fatalities:	0
LOCATION: 2150		BROADWAY & PAC				
11/15/1990	9:00 AM	TA	TS	LT		0

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION: 2150		BROADWAY & PAC				
4/10/2000	10:19 AM	TA	TS	LT/SD	N	0
			No. of accidents:	2	No. of fatalities:	0
LOCATION: 2155		3RD ST & PACIFIC				
9/19/1991	9:02 AM	TA	TS	LT		0
1/14/1992	1:21 PM	TA	TS	LT		0
6/26/1992	4:15 PM	TA	TS	LT		0
1/30/1993	11:42 AM	TA	TS	LT		0
4/2/1993	11:22 AM	TA	TS	LT		0
9/3/1993	4:47 PM	TA	TS	AE		0
1/20/1994	10:44 AM	TA	TS	LT		0
6/13/2000	2:47 PM	TA	TS	LT/SD	N	0
			No. of accidents:	8	No. of fatalities:	0
LOCATION: 2160		4TH ST & PACIFIC				
4/1/1991	9:43 AM	TA	TS	LT		0
4/9/1991	6:59 PM	TA	TS	LT		0
4/15/1992	8:55 AM	TA	TS	LT		0
			No. of accidents:	3	No. of fatalities:	0
LOCATION: 2170		5TH ST & PACIFIC				
6/9/1993	6:40 AM	TA	TS	LT		0
4/19/2002	5:47 PM	TA	TS	LT/SD	S	0
			No. of accidents:	2	No. of fatalities:	0
LOCATION: 2180		6TH ST & PACIFIC				
9/27/1993	11:59 AM	TA	TS	RS		0
4/28/1994	11:14 AM	TA	TS	AE		0
1/10/1995	5:01 PM	TA	TS	LT		0
6/12/1995	4:45 PM	TA	TS	AE		0
1/28/2000	6:21 PM	TA	TS	LT/SD	N	0
1/31/2003	1:06 PM	TA	TS	LT/SD	N	0
4/30/2003	12:57 PM	TA	TS	AE	N	0
			No. of accidents:	7	No. of fatalities:	0
LOCATION: 2190		7TH ST & PACIFIC				
11/25/1992	12:09 PM	TA	TS	LT		1
8/21/1996	11:03 PM	TA	TS	LT		0
1/13/1997	1:08 PM	TA	TS	LT/SD	N	0
2/2/1999	11:22 AM	TA	TS	WB/HR	N	0
11/18/1999	3:16 PM	TA	TS	LT/SD/PD	N	0

Date of Accident	Time of Accident	Type of Accident	Grade Crossing Type	Contributing Factor(s)	Direction of Travel (MBL)	Reported Fatalities
LOCATION: 2190		7TH ST & PACIFIC				
2/9/2003	8:20 PM	TA	TS	DR/RS/WB	N	0
2/11/2003	1:07 PM	TA	TS	LT/SD	N	0
4/5/2003	3:06 PM	TA	TS	LT/SD	N	0
3/18/2005	2:32 PM	TA	TS	AE	S	0
			No. of accidents:	9	No. of fatalities:	1
LOCATION: 2197		8TH ST & PACIFIC				
6/20/1994	6:51 PM	TA	TS	RT		0
7/5/1997	2:03 PM	TA	TS	AE	N	0
1/23/1998	5:38 PM	TA	TS	LT/AE	N	0
2/8/1999	5:43 PM	TA	TS	AE/HR	N	0
10/30/2000	5:27 PM	TA	TS	RS	N	0
3/12/2003	7:49 PM	TA	TS	RS/DR	N	0
2/3/2004	9:32 AM	TA	TS	LT/SD/HR	N	0
			No. of accidents:	7	No. of fatalities:	0
LOCATION: 2200		PINE & 8TH ST				
10/18/1990	2:35 PM	TA	TS	RS		0
11/19/1990	1:00 PM	TA	TS	RS		0
7/21/1998	7:05 PM	TA	TS	LT/SD	N	0
			No. of accidents:	3	No. of fatalities:	0
LOCATION: 2210		LOCUST & 8TH ST				
3/6/1999	6:24 PM	TA	TS	LT/SD	N	0
			No. of accidents:	1	No. of fatalities:	0
LOCATION: 2215		UNK 8TH STREET				
4/19/1994	9:00 AM	TA		AE		0
			No. of accidents:	1	No. of fatalities:	0
			Total no. of accidents:	758	Total no. of fatalities:	79

HOUSTON METRO TRAIN/VEHICLE AND TRAIN/PEDESTRIAN ACCIDENT/INCIDENT LIST

No.	Date	Day	N/P	Location	Description of Accident/ Incident	Time	Accident/ Incident	Condition	Major	Non-Major	Police Responded
1	1/9/04	Fri	N	Fannin and Binz	Vehicle turned left in front of train	8:25 AM	A	wet	Yes		Yes
2	1/12/04	Mon	N	2500 Main at 1000 McGowen	Vehicle made illegal left turn and kept going	1:39 PM	A				No
3	1/13/04	Tues	N	Fannin and University	O/V turned left in front of train	3:57 PM	A	Cloudy			No
	1/15/04	Thu	N	Fannin-Dryden Station- TMC TC	Boards near track struck train	6:43 PM	I	Rain			No
4	1/17/04	Sat	N	Fannin and Rosedale St	Vehicle heading WB failed to stop	10:23 AM	A	Wet			Yes
5	1/19/04	Mon	N	6600 Blk Fannin	Vehicle traveling NB on Fannin made an illegal left turn	2:00 PM	A	Clear	Yes		Yes
6	1/20/04	Tues	N	Fannin and Dryden Station	Vehicle made contact with LRV	9:35 AM	A	Clear			Yes
	1/20/04	Tues	N	Yard, Track 2 South	Derailment	3:20 AM	I				No
7	1/23/04	Fri	N	Test Track	Vehicle second passgr lifted rail to pass, contact made	9:00 AM	A	Cloudy	Yes		Yes
8	1/23/04	Fri	N	Fannin and TCH	Vehicle made contact with LRV by illegal left turn	4:08 PM	A	Cloudy			Yes
	1/26/04	Mon	N	Greenbriar and Braeswood	Passenger missed the step and fell getting off train	3:20 PM	I				No
9	1/26/04	Mon	N	Fannin and Southmore	Vehicle made illegal left turn	12:55 PM	A	Clear	Yes		Yes
10	1/27/04	Tues	N	2600 Main and McGowen	Vehicle heading NB made left turn, vehicle stopped on SB track	2:40 PM	A	Clear	Yes		Yes
				10 Accidents 3 Incidents					**5**	**0**	**8**
11	2/3/04	Tues	N	Fannin and Bellows TMC	Vehicle made illegal left turn	11:58 AM	A	Clear	Yes		Yes
12	2/15/04	Sun	N	Main and Pierce	Vehicle ran light EB on Pierce, made contact with train	10:39 PM	A	Clear	Yes		Yes

HOUSTON METRO TRAIN/VEHICLE AND TRAIN/PEDESTRIAN ACCIDENT/INCIDENT LIST

No.	Date	Day	N/P	Location	Description of Accident/ Incident	Time	Accident/ Incident	Condition	Major	Non-Major	Police Responded
13	2/19/04	Thur	N	Fannin and Palm	Vehicle exiting drive-in bank struck side of train	12:30 PM	A	Clear			Yes
14	2/21/04	Sat	N	Fannin and Montrose	Vehicle made illegal left turn	3:13 PM	A	Clear			Yes
15	2/24/04	Tues	N	Fannin and Dryden	Vehicle made illegal left turn	10:53 AM	A	Cloudy			Yes
16	2/27/04	Fri	N	Fannin and Southmore	Vehicle made illegal left turn	3:54 PM	A	Clear	Yes		Yes
17	2/27/04	Fri	N	San Jacinto and Montrose	Vehicle made illegal left turn	10:18 AM	A	Clear	Yes		Yes
				7 Accidents 0 Incident					**4**	**0**	**7**
18	3/1/04	Mon	N	San Jacinto and Southmore	Vehicle made sudden abrupt right turn	11:50 AM	A	Pt Cldy			Yes
19	3/3/04	Wed	N	Fannin and Rosedale	Vehicle ran red light which caused the contact with LRV	4:25 PM	A	Misty Rain			Yes
20	3/5/04	Fri	N	San Jacinto and Rosedale	Vehicle stationary on the lane adjacent to track 1	1:16 PM	A	Cloudy			Yes
21	3/10/04	Wed	N	NB Main and Gray Street	Vehicle collided with train	6:38 PM	A	Clear	Yes		Yes
22	3/15/04	Mon	N	NB Main and Gray Street	Vehicle made illegal left turn	1:47 PM	A	Cloudy			Yes
23	3/17/04	Wed	N	NB Fannin and Reliant Parkway	Pedestrian hit while running towards platform	4:01 PM	A	Clear	Yes		Yes
24	3/22/04	Mon	N	NB Main and Wheeler	Vehicle moved North onto track as train was approaching	9:04 AM	A	Clear	Yes		Yes
25	3/23/04	Tues	N	NB Fannin and SMLT/TCH	Vehicle made illegal left turn	4:56 PM	A	CLDY/WDY			Yes
26	3/24/04	Wed	N	NB S Braeswood & Greenbriar	Car was on wrong side of railroad arms	9:08 AM	A	Cloudy			Yes
27	3/27/04	Sat	N	Fannin and MacGregor	Pedestrian turned left off station close to track-way	2:29 AM	A	Sunny	Yes		Yes
28	3/29/04	Mon	N	SB Fannin and Binz	Vehicle stopped on tracks	4:20 PM	A	Cloudy	Yes		Yes
				11 Accidents 0 Incident					**5**	**0**	**11**

HOUSTON METRO TRAIN/VEHICLE AND TRAIN/PEDESTRIAN ACCIDENT/INCIDENT LIST

No.	Date	Day	N/P	Location	Description of Accident/ Incident	Time	Accident/ Incident	Condition	Major	Non-Major	Police Responded
29	4/2/04	Fri	N	NB Main and St. Joseph Pkwy	Vehicle ran light	7:03 PM	A	Rain			Yes
30	4/7/04	Wed	N	SB Fannin and John Freeman	Vehicle ran red light	12:28 PM	A	Cloudy			Yes
31	4/12/04	Mon	N	SB Fannin and Private Driveway	Motorist failed to stop at proper stop marker	10:07 AM	A	Rain			Yes
32	4/17/04	Sat	N	SB Fannin and Rosedale	Vehicle by-pass designated stopping point for traffic signal	1:23 PM	A	Clear	Yes		Yes
33	4/21/04	Tues	N	NB Fannin and Holly Hall	Vehicle made a right turn into the path of the train	16:51 PM	A	Pt Cldy	Yes		Yes
34	4/26/04	Mon	N	SB Main and Leeland	Elderly patron fell and hit on head on her way to seat	13:12 PM	A	Clear		Yes	No
				6 Accidents 0 Incident					**2**	**1**	**5**
35	5/4/04	Tues	N	NB Dryden and Ross Sterling	Vehicle failed to yield to right-of-way	8:00 AM	A	Clear			Yes
36	5/5/04	Wed	N	SB Fannin and Rosedale	Vehicle pulled out pass crosswalk and solid white lines fouling tracks	10:32 AM	A	Clear			Yes
37	5/9/04	Sun	N	SB Fannin and Dryden	Vehicle made a left in front of train	6:45 AM	A	Cloudy			Yes
	5/11/04	Tues	N	SB Main and Preston	Female passenger entering train and doors made contact w/ both sides of her body and re-opened	12:30 PM	I	Rain			No
38	5/14/04	Fri	N	SB Fannin and Rosedale	Vehicle ran red light which caused the contact with LRV	10:30 PM	A	Clear	Yes		Yes
	5/16/04	Sun	N	NB Fannin and Reliant Station	Passenger claimed door made contact with child	4:39 PM	I				No
39	5/25/04	Tues	N	SB 610 and Fannin	Vehicle nosed ahead of gate just following ROW	5:28 PM	A	Clear			No
40	5/27/04	Thur	N	NB Main and Congress	Vehicle made illegal left turn in front of train and made contact	2:05 PM	A	Clear			Yes

HOUSTON METRO TRAIN/VEHICLE AND TRAIN/PEDESTRIAN ACCIDENT/INCIDENT LIST

No.	Date	Day	N/P	Location	Description of Accident/ Incident	Time	Accident/ Incident	Condition	Major	Non-Major	Police Responded
				6 Accidents 2 Incidents					**1**	**0**	**5**
41	6/1/04	Tues	N	SB Fannin and Rosedale	Vehicle pulled out onto driveway	6:49 PM	A	Clear		Yes	Yes
42	6/7/04	Mon	N	Fannin and John Freeman	Vehicle made illegal left turn in front of train	11:00 AM	A	Clear			Yes
43	6/8/04	Tues	N	SB Pierce and Main	Vehicle made contact with train while turning	1:55 PM	A	Wet	Yes		Yes
44	6/16/04	Wed	N	3100 Main	Vehicle made an illegal left turn in front of the train	10:48 PM	A	Clear	Yes		Yes
45	6/17/04	Thurs	N	Main and Franklin	Vehicle made an illegal left turn in front of the train	10:02 PM	A	Clear			Yes
46	6/22/04	Tues	N	Main and Alabama	Vehicle ran the red light and collided with the train	4:24 PM	A	Cldy	Yes		Yes
				6 Accidents 0 Incident					**3**	**1**	**6**
47	7/1/04	Thurs	P	S. Dryden at Fannin	Vehicle turning left - train clipped rt rear side	6:38 PM	A	Clear			Yes
48	7/8/04	Thurs	N	806 Main street	Pedestrian jumped out in front of train (poss. suicide)	5:23 PM	A	Clear			Yes
49	7/13/04	Tues	N	Main at Texas	Vehicle made illegal left turn in front of train	12:14 PM	A	Clear			Yes
50	7/14/04	Wed	N	6600 Fannin	Van drifted into lane of the train	9:16 AM	A	Clear			Yes
51	7/16/04	Fri	N	Fannin at Dryden Station	Passenger injured when Opr hit maximum breaks	2:57 PM	A	Clear		Yes	No
52	7/22/04	Thurs	N	Fannin at Holly Hall	Vehicle made u-turn onto trackway	11:15 AM	A	Clear			YES
53	7/24/04	Sat	N	Main at Clay	Vehicle failed to stop at red signal- train hit	12:33 AM	A	Clear	Yes		Yes
54	7/28/04	Wed	N	500 Main at Texas	Vehicle made illegal left turn in front of train	8:33 PM	A	Clear			YES
55	7/29/04	Thurs	N	Fannin & Dryden	Vehicle made illegal left turn in front of train	9:39 AM	A	Clear			YES

HOUSTON METRO TRAIN/VEHICLE AND TRAIN/PEDESTRIAN ACCIDENT/INCIDENT LIST

No.	Date	Day	N/P	Location	Description of Accident/ Incident	Time	Accident/ Incident	Condition	Major	Non-Major	Police Responded
				9 Accidents 0 Incident					**1**	**1**	**8**
56	8/2/04	Mon	N	6500 Fannin @ University	Vehicle made illegal left turn	10:02 AM	A	Cloudy	Yes		Yes
	8/4/04	Wed	N	SB Main at Preston (Preston Station)	Train door hit lady (no medical treatment)	8:30 AM	I	Good			No
57	8/19/04	Thur	N	NB Main at Gray	Hit and Run vehicle ran red light	6:31 AM	A	Clear			Yes
58	8/20/04	Fri	N	Main @ Commerce	Vehicle turned right into the path of the train	11:25 AM	A	Ptly Cldy	Yes		Yes
59	8/24/04	Tues	N	Fannin @ N. MacGreggor	Vehicle disregarded traffic signal	8:05 AM	A	Clear			No
60	8/25/04	Wed	N	Main @ Pierce	Vehicle disregarded traffic signal	11:01 PM	A	Clear	Yes		Yes
				5 Accidents 1 Incident					**3**		**4**
61	9/7/04	Tues	N	Main at Webster	Vehicle backed into train	5:30 PM	A	Clear			Yes
62	9/14/04	Tues	N	Main at Lamar	Pedestrian disregarded traffic control signal (walked into rear of train)	10:53 PM	A	Clear	Yes		Yes
	9/19/04	Sun		Fannin at Southmore	Train blew horn - vehicle rushed through intersection	10:45 AM	I	Clear			Yes
63	9/19/04	Sun		Pierce at Main	Vehicle and Train collided in intersection	3:57 PM	A	Clear	Yes		Yes
				3 Accidents 1 Incident					**2**		**4**
64	10/4/04	Mon	N	Fannin at Holly Hall	Pedestrian walked into side of train	8:10 AM	A	Cldy	Yes		Yes
65	10/6/04	Wed	P	Main at Walker	Pedestrian jay walking across street in front of train	7:24 AM	A	Clear	Yes		Yes
66	10/8/04	Fri	N	Main at Franklin	Vehicle made an illegal left turn in front of the train	9:55 AM	A	Cldy		Yes	Yes

HOUSTON METRO TRAIN/VEHICLE AND TRAIN/PEDESTRIAN ACCIDENT/INCIDENT LIST

No.	Date	Day	N/P	Location	Description of Accident/ Incident	Time	Accident/ Incident	Condition	Major	Non-Major	Police Responded
67	10/22/04	Fri	N	Main at Jefferson	Vehicle disregarded traffic signal	4:55 PM	A	Clear	Yes		Yes
				4 Accidents 0 Incident					**3**	**1**	**4**
68	11/13/04	Sat	N	Downtown Transit Center	Patron missed step & fell - transported to St. Joseph Hospital	11:00 AM	A	Cldy		Yes	Yes
	11/18/04	Thurs	N	Fannin at Ross Sterling	Vehicle cited for unsafe lane change	9:33 AM	I	Clear			Yes
69	11/18/04	Thurs	N	Fannin South Track 2	Patron missed step & fell near seat	12:00 PM	A	Clear		Yes	Yes
				2 Accidents 1 Incident					**0**	**2**	**3**
70	12/15/04	Wed	N	1700 Main at 900 Jefferson	Vehicle made an illegal left turn	8:30 AM	A	Clear			Yes
71	12/30/04	Thurs	N	1900 Main at Pierce	Vehicle failed to obey traffic signal	3:00 PM	A	Clear		Yes	Yes
				2 Accidents 0 Incident					**0**	**1**	**2**
1	01/07/05	Friday	N	2000 Main @ 900 Gray	Vehicle failed to obey traffic signal	7:30 PM	A	Clear	Yes		Yes
2	01/11/05	Monday	N	Fannin @ University Blvd.	Vehicle made an illegal left turn	2:00 PM	A	Clear	Yes		Yes
3	01/11/05	Monday	N	U of H Platform	Pssgr fell hitting head when exiting train	11:33 AM	A	Clear		Yes	No
4	01/26/05	Wed	P	Fannin @ Herman Drive	Vehicle failed to obey traffic signal	10:04 AM	A	Clear	Yes		Yes
5	01/27/05	Thurs	N	Fannin @ MacGregor	Vehicle changed lanes into the train	3:10 PM	A	Clear	Yes		Yes
6	01/27/05	Thurs	N	San Jacinto @ Witchita	Vehicle failed to stop at designated stop	8:45 AM	A	Clear	Yes		Yes

HOUSTON METRO TRAIN/VEHICLE AND TRAIN/PEDESTRIAN ACCIDENT/INCIDENT LIST

No.	Date	Day	N/P	Location	Description of Accident/ Incident	Time	Accident/ Incident	Condition	Major	Non-Major	Police Responded
				5 Accidents 0 Incident					**5**	**1**	**5**
7	02/10/05	Thurs	N	Fannin @ University	Vehicle made an illegal left turn	5:03 PM	A	clear	Yes		Yes
	02/12/05	SAT	N	Fannin @ Oakdale	Vehicle pulled out of a driveway and collided with train	2:54 PM	A	clear			Yes
				2 Accidents 0 Incident					**1**		**2**
8	3/4/2005	FRI	N	Main @ McKinney	Vehicle failed to obey traffic signal	7:34 AM	A	Clear			Yes
9	03/13/05	SUN	N	Reliant Station & Old Main	Vehicle made an illegal left turn	4:36 PM	A	Clear			Yes
	03/14/05	MON	N	Fannin @ Ross Sterling	Vehicle made an illegal left turn	2:18 PM	A	Clear			Yes
10	03/16/05	Wed	N	Fannin @ Dryden	Vehicle turned into path of train	3:19 PM	A	Cldy	Yes		Yes
11	3/18/05	Fri	N	San Jacinto @ Herman	Vehicle pulled onto trackway directly in front of train	5:21 AM	A	Clear			Yes
12	03/22/05	Tues	N	Main @ Capitol	Vehicle made an illegal left turn	12:20 PM	A	Clear			Yes
				6 Accidents 0 Incident					**1**	**0**	**6**
13	4/2/2005	Sat	N	Main @ Pease	Vehicle made illegal left turn	2:08 PM	A	Clear	Yes		Yes
14	04/10/05	Sun	N	Main @ Webster	Vehicle ran red light	12:32 PM	A	Clear	Yes		Yes
	04/18/05	Mon	N	Main @Rusk	Vehicle made illegal left turn	6:38 AM	A	Clear			Yes
15	04/20/05	Wed	N	Fannin @ Memorial Herman Stat	Pedestrian stepped into path of train	9:02 AM	A	Clear		Yes	Yes
16	04/25/05	Mon	N	Main @ Alabama	Vehicle ran red light	3:33 PM	A	Clear		Yes	Yes
				5 Accidents 0 Incident					**2**	**2**	**5**

HOUSTON METRO TRAIN/VEHICLE AND TRAIN/PEDESTRIAN ACCIDENT/INCIDENT LIST

No.	Date	Day	N/P	Location	Description of Accident/ Incident	Time	Accident/ Incident	Condition	Major	Non-Major	Police Responded
17	5/1/2005	Sun		Main @ Lamar	Pssgr fell exiting train - transport	6:25 PM	A	Clear		Yes	No
	5/2/2005	MON		MAIN @ DALLAS	PED RAN INTO TRAIN-NO TRANSPORT	8:14 AM	I	CLEAR			No
18	05/09/05	Mon		Fannin @ Texas Children's Hos	Vehicle made illegal lane change	3:03 PM	A	Clear	Yes		Yes
19	05/10/05	Tues		Main @ Jefferson	Vehicle ran red light - FATALITY	10:23 PM	A	Clear	Yes		Yes
20	05/13/05	Fri		Main @ Jefferson	Vehicle ran red light	6:18 AM	A	Clear	Yes		Yes
21	05/16/05	Mon		Main @ McGowen	Vehicle ran red light & hit train	4:55 PM	A	Clear		Yes	Yes
				5 Accidents 1 Incident					**3**	**2**	**4**
	6/2/005	Thurs		Fannin / Ross Sterling	Pick Up came into shared left turn (H & R)	6:24 AM	I	Clear			Yes
22	06/04/05	Sat		Fannin / Wichita	Truck pulled onto trackway contact w/train	10:09 AM	A	Clear			No
	06/06/05	Mon		Main / Preston	Traffic pole bent into trackway by unknown source train struck	8:05 AM	I	Clear			No
23	06/13/05	Mon		Fannin / TCH	Vehicle turned into shared left turn lane	9:08 AM	A	Clear			Yes
24	06/15/05	Wed		Main at Dallas	Vehicle ran red light	10:37 PM	A	Clear	Yes		Yes
25	06/15/05	Wed		Museum District Station	Train stopped - child fell	1:40 PM	A	Clear		Yes	
26	06/21/05	Tues		Main at Alabama	Vehicle ran red light	10:21 AM	A	clear			Yes
				5 Accidents 2 Incidents					**1**	**1**	**4**
27	07/05/05	Tues		Main / St Joseph	Vehicle turned left in front of train	5:45 PM	A	Clear	Yes		Yes
28	07/19/05	Tues		Greenbriar / OST	Vehicle ran red light from turn lane	10:06 PM	A	Clear			Yes
29	07/20/05	Wed		5200 Fannin	Vehicle pulled out of private drive	12:03 PM	A	Clear		Yes	Yes

HOUSTON METRO TRAIN/VEHICLE AND TRAIN/PEDESTRIAN ACCIDENT/INCIDENT LIST

No.	Date	Day	N/P	Location	Description of Accident/ Incident	Time	Accident/ Incident	Condition	Major	Non-Major	Police Responded
30	07/22/05	Fri		Fannin / Wichita	Vehicle pulled out in front of train	12:12 PM	A	Clear	Yes		Yes
31	07/26/05	Tues		Fannin - TCH	Ambulance cut into train	4:44 PM		Clear			Yes
32	07/28/05	Thur		Fannin / Binz	Vehicle ran red light	9:15 AM	A	Clear			Yes
33	07/28/05	Thur		Main / McGowan	Pedestrain crossing street against the light in front of train	4:48 PM	A	Clear	Yes		Yes
				6 Accidents 0 Incident					**3**	**1**	**7**
	08/10/05	Wed		Fannin - TCH	Vehicle sideswiped train	2:05 PM	A	Clear			Yes
	08/12/05	Fri		Fannin - TCH	Vehicle turned into shared left turn left in front of train	2:10 PM	A	Clear			Yes
	08/17/05	Wed		Fannin - TCH	Vehicle merged into shared left turn left into the train	11:39 AM	A	Clear			No
	08/26/05	Fri		Main at Dallas	Vehicle made an illegal left turn in front of train	2:59 PM	A	Clear			No
				4 Accidents 0 Incident					**0**	**0**	**2**
34	09/03/05	Sat		Naomi / Fannin	Pedestrian walked into path of train - head phones on	11:22 AM	A	Clear	Yes		Yes
35	09/06/05	Thurs		San Jacinto / Ewing	Vehicle turned right in front of train	4:01 PM	A	Clear	Yes		Yes
36	09/08/05	Sat	P	Main / Leeland	Train proceeded through intersection hit by vehicle- not vertical bar	3:57 PM	A	Clear	Yes		Yes
				3 Accidents 0 Incident					**3**	**0**	**3**
37	10/01/05	Sat		Fannin / Mac Gregor	Vehicle failed to stop at traffic device	2:10 PM	A	Clear	Yes		Yes
38	10/02/05	Sun		Main / Alabama	Vehicle turned right onto Main causing the train to hit its left rear bumper	5:15 PM	A	Clear	Yes		Yes

HOUSTON METRO TRAIN/VEHICLE AND TRAIN/PEDESTRIAN ACCIDENT/INCIDENT LIST

No.	Date	Day	N/P	Location	Description of Accident/ Incident	Time	Accident/ Incident	Condition	Major	Non-Major	Police Responded
39	10/10/05	Mon		Main / McGowen	WC rolled into path of train	11:50 AM	A	Rain	Yes		Yes
40	10/20/05	Thurs		Fannin / McGregor	Vehicle ran red light	5:18 AM	A	Clear	Yes		Yes
41	10/21/05	Fri		Fannin / Southmore	Vehicle failed to stop-hit train on side	1:15 PM	A	Clear			Yes
42	10/28/05	Fri	P	San Jacinto & Rosedale	Train hit vehicle crossing intersection	1:53 PM	A	Clear			Yes
				6 Accidents 0 Incident					**4**	**6**	**6**
43	11/03/05	Thurs	N	Main / Capital	Vehicle ran light - train hit	11:02 AM	A	Clear	Yes		Yes
44	11/06/05	Sun	N	Fannin/ N. McGregor Way	Vehiduar accident - pushed van into stopped train	5:10 PM	A	Clear		Yes	Yes
45	11/07/05	Mon	N	Main / Pierce	Vehicle ran light hit train in the side	5:13 PM	A	Clear		Yes	Yes
46	11/17/05	Thurs	N	Fannin / TCH	Vehicle turned into shared lane hitting train	2:32 PM	A	Clear			Yes
				4 Accidents 0 Incident					**1**	**2**	**4**
47	12/01/05	Thurs	N	San Jacinto / Southmore	Vehicle pulled past stop line-train hit front	10:11 AM	A	Clear			Yes
48	12/07/05	Wed		Fannin/Oakdale	Vehicle turned left in front of LRV	7:01 PM	A	Rainy			Yes
49	12/15/05	Thurs		Fannin/Dryden	Vehicle swerved in front of train	12:40 PM	A	Clear			Yes
50	12/17/05	Sat		Main/Pierce	Vehicle ran light-hit train/No Inj	3:47 PM	A	Clear		Yes	Yes
51	12/23/05	Fri		Main/Elgin	Vehicle ran light/hit train-7 Inj w/transport	12:32 PM	A	P. Cldy	Yes		Yes
52	12/27/05	Tues.		San Jacinto/Southmore	Car didn't stop @ red light/hit train-No Inj	12:00 PM	A	Clear		Yes	Yes
				6 Accidents 0 Incident					**1**	**2**	**6**

HOUSTON METRO TRAIN/VEHICLE AND TRAIN/PEDESTRIAN ACCIDENT/INCIDENT LIST

No.	Date	Day	N/P	Location	Description of Accident/ Incident	Time	Accident/ Incident	Condition	Major	Non-Major	Police Responded
1	01/03/06	Tues	N	Main/Walker	Vehicle failed to stop at red light-No Inj	7:23 PM	A	Clear			Yes
2	01/04/06	Wed	N	Fannin/Binz	Vehicle ran signal light-Driver of O.V transp.	8:02 PM	A	Clear	Yes		Yes
3	01/04/06	Wed	N	Main/Lamar	Blind pdstrn. Walked in path of train/was transp.	11:39 AM	A	Clear		Yes	Yes
4	01/27/06	Friday	N	Main / St Joseph Pkwy	Vehicle disregarded traffic signal	6:56 AM	A	Clear			Yes
				4 Accidents 0 Incident					**1**	**1**	**4**
5	02/08/06	Wed	N	Main / Lamar	Vehicle failed to stop at red light-No Inj	8:08 PM	A	Clear			Yes
6	02/18/06	Sat	N	Main / St Joseph Pkwy	Vehicle failed to stop at red light-No inj	11:46 AM	A	Clear	Yes		Yes
7	02/19/06	Sun	N	Fannin / Braeswood	Vehicle failed to stop at RR arm	8:39 PM	A	Clear			Yes
8	02/23/06	Thurs	P	Fannin/ N. McGregor	LRV m/cont w/vehicle in shared left turn lane-3 vehicle chain reaction occurred	7:43 AM	A	Drizzle		Yes	Yes
				4 Accidents 0 Incident					**1**	**1**	**4**
9	03/04/06	Sat	N	Museum Station	Pssgr jumped up to catch train-fell	4:17 PM	A	Clear		Yes	Yes
10	03/07/06	Tues	N	Fannin / Holly Hall	Truck pulled into path of train	12:50 PM	A	Clear			Yes
11	03/17/06	Fri	N	San Jacinto/Arbor	Vehicle pulled into path of train	12:20 PM	A	Clear			Yes
12	03/20/06	Mon	N	Main / Elgin	Vehicle ran red light hit train	12:26 PM	A	Clear			Yes
				4 Accidents 0 Incident					**0**	**1**	**4**
13	04/20/06	Thurs	N	Fannin -Dryden	Train Stopped - Pssgr fell on steps	4:42 PM	A	Clear		Yes	No
14	04/25/06	Tues	N	San Jacinto / Witchita	Vehicle turned right in front of train	3:32 PM	A	Clear			Yes

HOUSTON METRO TRAIN/VEHICLE AND TRAIN/PEDESTRIAN ACCIDENT/INCIDENT LIST

No.	Date	Day	N/P	Location	Description of Accident/ Incident	Time	Accident/ Incident	Condition	Major	Non-Major	Police Responded
15	04/25/06	Tues	N	Main / McGowen	Pssgr fell backwards-hit head on floor	11:25 AM	A	Clear		Yes	No
				3 Accidents 0 Incident					**0**	**2**	**1**
16	05/02/06	Tues	N	San Jacinto/Wichita	Truck turned into path of train	9:45 AM	A	Clear	Yes		Yes
17	05/12/06	Fri	N	Fannin / Herman	Truck turned left in front of train	11:25 AM	A	Clear		Yes	Yes
18	05/13/06	Mon	N	Main / Alabama	Vehicle ran red light	2:55 PM	A	Clear	Yes		Yes
19	05/31/06	Wed	N	Main / Pierce	LRV going through intersection vehicle hit at 3rd door	5:30 AM	A	Rain	Yes		Yes
				4 Accidents 0 Incident					**3**	**1**	**3**
20	06/07/06	Wed	N	Main / Walker	Truck swerved into train avoiding a vehicle	2:27 PM	A	Clear			Yes
21	06/14/06	Wed		San Jacinto/Southmore	Vehicle made illegal right turn into train	3:42 PM	A	Clear			Yes
22	06/18/06	Sun		Main / Elgin	Vehicle pulled into path of train-h & r	2:54 PM	A	Clear	Yes		Yes
23	06/21/06	Wed		Fannin at TCH	Vehicle veered into path of train-hit	8:52 AM	A	Clear			Yes
24	06/25/06	Sun		Fannin South Station	Pssgr fell getting out of seat - hit head-trans	10:47 AM	A	Clear		Yes	No
				5 Accidents 0 Incident							
25	07/03/06	Mon		Main / St Joseph	Truck made illegal left turn into the path of the train	10:50 AM	A	Cldy	Yes		Yes
				1 Accident 0 Incident					**1**	**0**	**1**
26	09/03/06	Sun		San Jacinto / Southmore	Vehicle ran red light train hit side near back of vehicle	4:58 PM	A	Clear	Yes		Yes

HOUSTON METRO TRAIN/VEHICLE AND TRAIN/PEDESTRIAN ACCIDENT/INCIDENT LIST

No.	Date	Day	N/P	Location	Description of Accident/ Incident	Time	Accident/ Incident	Condition	Major	Non-Major	Police Responded
27	09/11/06	Mon		Greenbriar / OST	Van turned left in front of train	1:28 PM	A	Clear			Yes
28	09/15/06	Fri		Main / Jefferson	Truck turned left in front of train	11:46 PM	A	Clear	Yes		Yes
				3 Accidents 0 Incident					**2**	**0**	**3**
29	10/14/06	Sat	N	Main / Pierce	Vehicle turned right onto Main hit train head on	12:11 AM	A	Clear			Yes
				1 Accident 0 Incident							
30	11/02/06	Thurs	N	Fannin / Bellow	Vehicle made left turn into pathway of train	1:28 PM	A	Clear			Yes
				1 Accident 0 Incident					**0**	**0**	**1**

Maryland Transit Administration

MARYLAND TRANSIT ADMINISTRATION

MARYLAND DEPARTMENT OF TRANSPORTATION

Robert L. Ehrlich, Jr., Governor • Robert L. Flanagan, Secretary • Lisa L. Dickerson, Administrator

TO: Mr. Ahmed Simier
207 Engineering South
School of Civil Engineering
Okalahoma State University
Stillwater, OK. 74078

FROM: Sheila Epps
Assistant Safety Data Analyst
1515 Washington Boulevard Suite 2200-B
Baltimore, Maryland 21230

RE: Light Rail Safety Analysis for the Howard Street Corridor
From Conway Street to Mount Royal Avenue/Dolphin Street,
Baltimore, Maryland

Mr. Simier,

Enclosed please find the data you request three weeks ago. If any additional data is need please call me at 410-454-762 from 8:30am to 4:00 pm Monday through Friday or e-mail me. Sorry for any inconvenience I may have cause your.

Summary
PDO: Property Damage
Injury Accident: Pedestrian and or passengers
Fatal Accidents: Fatalities

Sheila Epps
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Baltimore, Maryland 21230
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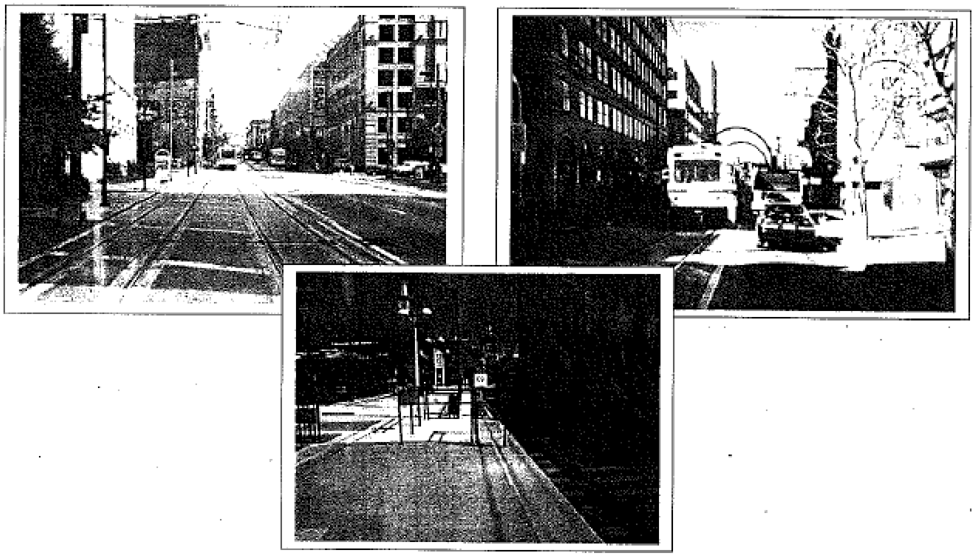
Light Rail Safety Analysis for The Howard Street Corridor from Conway Street to Mount Royal Avenue/Dolphin Street, Baltimore, Maryland



Prepared for:

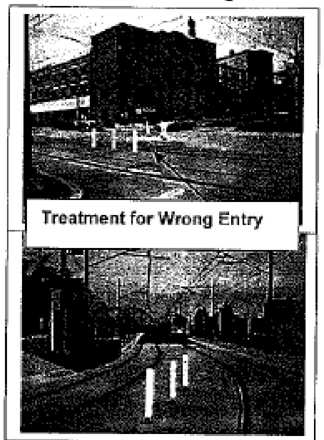
The Maryland Transit Administration
6 St. Paul Street
Baltimore, MD 21202

Prepared by:
Sabra, Wang & Associates, Inc.

December 18, 2006

pavement marking delineation and pavement texture treatments. The number of accidents at these two intersections was reduced from 5 and 6 in 2002 and 2003, respectively to only 3 in 2004.

Howard Street at Mt. Royal/Dolphin Streets: This intersection is the northern most crossing in the Howard Street LRT corridor, and adjacent to an LRT station. This intersection is on a downgrade. In the past years, two factors have contributed to several accidents. Sideswipe collisions with parked vehicles also have occurred along the curb path of LRVs on Dolphin Road. Secondly, accidents have also occurred in the middle of the intersection and at the entry to the LRT tracks, mainly because of confusion associated with the vehicle path to the travel lanes at this skewed intersection.



Treatment for Wrong Entry

Treatments for these problems have included the installation of concrete bollards adjacent to the curb to eliminate any potential contacts with LRVs; installation of a concrete island and reflective post-mount delineators to channelize vehicle path and reduce sideswiping LRVs.

Other Corridor Improvements: In addition to the intersection specific improvements, others have included replacing all green ball lenses with arrow lenses where applicable; replacing left and right turn prohibition regulatory signs with R3-1 and R3-2 signs with track symbols; installing new R10-6 "Stop Here On Red", R8-8 "Do Not Stop on Tracks", and R15-6 "Look Both Ways" at unsignalized intersections; and renewing all dynamic envelope and lane markings throughout the corridor with paint markings.

VII. ROAD SAFETY AUDIT FOLLOW-UP CORRECTIVE MEASURES

Accident data was collected for 2002 through 2005. The data is summarized in Tables 4 through 6, and shows that the number of accidents and accident rates were reduced in spite of a modest increase (2 to 3 percent per year) in traffic volumes on Howard Street and cross arterials.

In 2002, light rail service on Howard Street was suspended for three months because of a tunnel fire under the tracks. In late 2003 and early 2004, the light rail operation for the southbound track on Howard Street was also suspended because of the double tracking project. Nevertheless, more than 75-percent of all light rail accidents in the previous years had occurred with LRVs traveling on the northbound track. The severity of accidents reported below also indicates a favorable benefit for the enhancements implemented in late 2002 and 2003.

Table 4. Number, rate, claims and severity of accidents (2002-2004)

Year	Number of Accidents	Rate of Accidents per MVM	Claims Paid Out ($)
2002	35	12.56	$110
2003	42	15.56	$11,539
2004	22	13.40	$7,833
2005	11	8.60	0
Total	**110**	12.53	$19,482

Year	PDO Accidents	Injury Accidents	Fatal Accidents
2002	20	14	1
2003	29	13	0
2004	15	7	0
2005	7	4	0
Total	**71**	**38**	1

Over this four-year period (2002-2005), the accident rate was also reduced by 18-peecent, compared to the 1999-2000 accident rate. Likewise, the paid out claims also were reduced by 82-percent, indicating a significant reduction in the severity of accidents.

Improvements in 2005 focused on left and right-turn restrictions, wrong entry delineation and physical separation between LRV tracks and other vehicular traffic. For example, active blank-out signs were installed at several intersections including on Howard Street at Conway St/Camden Yard Entrance; Lombard St.; Madison St.; and Preston Street. Likewise, Wrong Way Entry delineation was added at Mt. Royal Avenue and Dolphin Street in addition to flexible posts delineators and curb delineation as well.

The intersections listed in **Table 5** continued to dominate the total number of accidents. The intersection of Lombard Street at Howard Street was noted with a continuing trend of only left-turn accidents. All other types of accidents were reduced. The intersection of Howard Street at Lexington Street demonstrated a significant reduction in the total number of accidents, compared to the previous years from 1999 to 2001. Likewise, the section between Pratt Street and Lombard Street experienced a significant reduction in sideswipe, left-turn and pedestrian accidents; also similar results were reported for the section between Baltimore Street and Lexington Street. Overall, the benefits of the low cost improvements identified earlier in this paper demonstrated a favorable return in terms of a reduced accident rate and severity.

Table 5. Most frequent accident intersections (2002-2005)

Intersection of Howard Street at	% Of Total Accidents
Pratt St.	10%
Lombard St.	**15% (increased)**
Baltimore St.	9%
Fayette St.	9%
Lexington St.	**8% (reduced)**
Read/Chase	6%
MLK, Jr. Blvd.	8%
Mt. Royal/Dolphin	**3% (reduced)**
Total	**68%**

The most frequent types of accidents for the reported period of 2002 to 2004 did not show a significant change in accident patterns. The most reported change was for sideswipe and left-turn accidents where both were reduced by a few percents. The number of right-turn accidents increased by 3-percent.

Table 6. Accident frequency by type (2002-2005)

Accident Type	Percentage
Sideswipe	**29% (reduced)**
Left-Turn	**24% (reduced)**
Angle	**21% (no change)**
Pedestrian	**9%(no change)**
Parking	**0%(minor change)**
Backing	**0% (minor change)**
Right-Turn	**8% (increased)**
Rear-End	**1% (no change)**
Opposite Direction	**2% (no change)**

VIII. SUMMARY

In performing both safety studies it became apparent that all safety improvements have positive impacts on the safety and operations of light rail, pedestrians and all vehicular traffic. The MTA has taken a proactive approach to mitigate potential safety problems.

In total, the MTA spent approximately $220K for all safety improvements since 1999. The cost of these improvements has paid off in reducing accident severity, paid out claims and public acceptance. The MTA continues to improve the operations and safety for the Howard Street Light Rail Corridor. Several improvements are planned for next year and include additional activated blank out signs (R3-2a, R3-1a and W 10-7) at locations that have recurring right-turn and left-turn crashes.

One particular finding of the study is that uniformity and consistency in the application of signs and pavement markings is paramount for controlling certain types of accidents. Specifically, the delineation of the dynamic envelope proved to be a very cost effective measure to reduce sideswipe accidents in travel sections where the travel lanes are less than 12 feet wide.

The concept of a flexible barrier separation between LRVs and other vehicular traffic, although expensive, proved to be one of the most positive treatments to prohibit illegal turning movements, minimize sideswipe accidents and reduce accident severity. Part 10 of the current MUTCD edition provides an added value with its recent guidelines and standards for Traffic Control for Highway-Light Rail Transit Grade Crossings. Maintaining conformity with these guidelines enables an agency to maintain consistency in implementing various traffic control devices as corrective measures for potential safety problems. This study demonstrated that low cost improvements have immediate measurable benefits.

The quickness and positive outcome of the light rail safety study has motivated the MTA to continue implementing additional safety improvements. Several improvements were added in late 2005 and include activated blank out signs (R3-2a, R3-1a and W 10-7) at five locations that have recurring right-turn and left-turn accidents. Safety data will be collected at these locations for the next two years to assess the effectiveness of the corrective measures. However, as of now, the results have been very promising.

The MUTCD 2003 and other resources, specifically the Transportation Research Board TCRP Report 17, "Integration of Light Rail Transit into City Streets"; and the California Traffic Control Devices Committee Report, "Light Rail Traffic Manual", 1994

Edition, proved to be very instrumental in guiding the safety audit process for identifying and mitigating problem areas.

IX. RECOMMEDNADTIONS

Renewing the pavement markings and delineation for the dynamic envelope should be performed annually. Based on our experience in the Howard Street Corridor, pavement markings paint tends to wear off quickly, within a year. Using an alternate type of pavement markings such as thermoplastic tape is recommended. The application of Bedstead railing at stations is very effective and should be considered for all stations, where applicable. Making provisions for a lag left-turn phase in the same direction of light rail movement is highly recommended to reduce the number of left-turn and red light running accidents. The use of a low-cost physical separation between travel lanes and LRT tracks is highly recommended; it proved to be very cost effective for this study; alternates include reflective flexible tubes, portable mountable curbs and/or both. Blank-out signs have proven to be are very effective positive guidance measures to alert motorists of prevailing turning conditions.

Overall, the physical improvements made by the MTA have resulted in positive safety results and have reduced the frequency and severity of crashed substantially.

Salt Lake City (UTA) LRT

Fatal Collisions with Pedestrian

Year	Pedestrian Fatalities	Train Speed, mph
2000	1	55
2001	0	
2002	1 1	55 25
2003	0	
2004	1	25
2005	0	
2006	0	