Transit Cooperative Research Program
Sponsored by the Federal Transit Administration
RESEARCH RESULTS DIGEST
November 2002—Number 51

Subject Areas: VI Public Transit and VII Rail
Responsible Senior Program Officer: S. A. Parker

Second Train Coming Warning Sign Demonstration Projects

This TCRP digest summarizes the results of two demonstration projects concerning second train coming warning signs for light rail transit systems. The demonstrations 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 with funding through TCRP Project A-5A, "Active Train Coming/Second Train Coming Sign Demonstration Project." The MTA report was prepared by Sabra, Wang, & Associates, Inc. The LACMTA report was prepared by PB Farradyne.

A challenging problem that many light rail systems face is the "second train coming" phenomenon on double track crossings. A second train frequently activates the grade crossing equipment within seconds after the first train has activated the grade crossing circuits, thus creating a situation in which two trains pass through the grade crossing within seconds of each other. This situation is very confusing and potentially dangerous to motorists and pedestrians. This digest provides the results of two demonstrations of active sign warning systems that could increase awareness of and compliance with the conditions of the second train coming phenomenon. Demonstrations were conducted at the Maryland Mass Transit Administration's Baltimore Central Light Rail Line system and the Los Angeles County Metropolitan Transportation Authority's Metrorail Blue Line.

PART 1: LOS ANGELES COUNTY METROPOLITAN TRANSPORTATION AUTHORITY

Abstract: The Los Angeles Metro Blue Line demonstration project was carried out to investigate the use of a train-activated warning sign as a means of reducing the added hazard for pedestrians of two trains in a highway-railroad intersection (HRI) at the same time. The demonstration project was conducted at one of the Metro Blue Line's most hazardous HRIs, on the south sidewalk at the Vernon Avenue intersection with the Metro Blue Line and Union Pacific Railroad (UPRR) tracks. The sidewalk crosses two light rail transit (LRT) tracks and two UPRR freight tracks. From the analysis of before and after video data, the demonstration project found that the warning sign was effective in reducing risky behavior by pedestrians. Overall, the number of pedestrians crossing the LRT tracks at less than 15 seconds in front of an approaching LRT train was reduced by 14 percent after the warning sign was installed. The number of pedestrians crossing the tracks at 6 seconds or less before an LRT train entered the crossing was reduced by about 32 percent. The number of pedestrians crossing the tracks at 4 seconds or less in front of an approaching LRT train was reduced by 73 percent, an impressive decline in this type of especially risky behavior.

PART 2: MARYLAND MASS TRANSIT ADMINISTRATION

Abstract: One of the most challenging aspects that the Maryland Mass Transit Administration's (MTA's) Baltimore Central Light Rail Line system has experienced is the "second train coming" (STC) phenomenon on double track crossings. The objective of this project was to test an active sign warning system that could increase motorists' awareness of and compliance with the conditions of an STC phenomenon. The employment of a 128-frame, animated light emitting diode sign at the Timonium Road crossing resulted in a significant reduction in risky behavior by drivers. The STC sign was well received and understood by motorists.

PART 1: LOS ANGELES COUNTY METROPOLITAN TRANSPORTATION AUTHORITY

CONTENTS

SUMMARY

The Metro Blue Line (MBL) is a 22-mile light rail transit system running between downtown Los Angeles and the City of Long Beach. MBL trains, running at speeds of up to 55 miles per hour, traverse 100 grade crossings. Many of the highway-railroad intersections (HRIs) are located at major streets carrying high traffic volumes. Following the startup of MBL operations in 1990, there was a large number of train/vehicle and train/pedestrian collisions at HRIs. As the result of a number of HRI safety improvement projects undertaken by the Los Angeles County Metropolitan Transportation Authority (LACMTA), the accident rate has been significantly lowered. However, there have been continuing problems with certain types of train/vehicle and train/pedestrian accidents at selected locations, one being train/pedestrian collisions at crossings situated adjacent to stations.

An important contributing factor for many train/vehicle and train/pedestrian collisions has been the presence of a second train, either a slower-moving freight train or a second light rail transit (LRT) train. Often, motorists and pedestrians may be acting in a manner they thought was safe, such as avoiding slow-moving freight trains or crossing the tracks when there is an LRT train stopped at a nearby station, but their actions have resulted in collisions with second trains.

This demonstration project was carried out by the LACMTA, with funding support provided by the U.S. Department of Transportation Federal Transit Administration (FTA) under the Transit Cooperative Research Program (TCRP), to investigate the use of a train-activated warning sign as a means of reducing the added hazard for pedestrians of two trains in an HRI at the same time. The Vernon Avenue HRI, shown in Figure 1, was selected as the location for this demonstration project.

The demonstration project was conducted at one of the MBL's most hazardous HRIs, at Vernon Avenue in the City of Los Angeles. The project was carried out on the south sidewalk at the Vernon Avenue intersection with the MBL and Union Pacific Railroad (UPRR) tracks. The sidewalk crosses two LRT tracks and two UPRR freight tracks. The entrance to the Vernon Avenue MBL station is located between the normally northbound and normally southbound LRT tracks. There have been 17 train/pedestrian collisions at the Vernon Avenue HRI since 1990. Five of the collisions have resulted in fatalities, although one of the collisions was determined to be a suicide.

The effectiveness of the second train warning sign was evaluated using two approaches. First, before and after data regarding risky crossings by pedestrians was collected and analyzed. The data was collected by viewing video tapes recorded at the crossing where the video camera was activated only when there were two trains at or in the vicinity of the crossing. Second, an intercept survey of pedestrians at the Vernon Avenue crossing was conducted to gauge pedestrian awareness of the second train warning sign and, more importantly, understanding of its warning message.

From the analysis of before and after data, the demonstration project found that the warning sign was effective in reducing risky behavior by pedestrians at the Vernon Avenue crossing. Overall, the number of pedestrians crossing the LRT tracks at less than 15 seconds in front of an approaching LRT train was reduced by 14 percent after the warning sign was installed.

The number of pedestrians crossing the tracks at six seconds or less before an LRT train entered the crossing was reduced from 59 to 40, a reduction of about 32 percent. The number of pedestrians crossing the tracks at four seconds or less in front of an approaching LRT train was reduced from 15 to 4, a substantial 73-percent decline in this type of especially risky behavior. These reductions are the most significant findings from the demonstration project.

The intercept survey found that most pedestrians were aware of the second train warning sign and interpreted the sign as a warning sign, although only a few pedestrians interpreted the sign as meaning that there were two trains at the same time at or in the vicinity of the crossing.

Of the 556 pedestrians interviewed, more than three-quarters (77 percent) recalled having seen the warning sign. Only four percent of pedestrians directly related the sign to the presence of two trains, although the overwhelming majority of respondents were aware that the sign indicated danger. A total of 92 percent of respondents interpreted the sign in such a way that would increase their safety near the tracks either by stopping, looking both ways, or otherwise taking precautions.

The majority of intercept survey respondents (93 percent) believe that the second train warning sign improves safety at the Vernon Avenue crossing to either a great extent (63 percent) or some extent (30 percent).

Using the results of the demonstration project, the LACMTA will determine whether to implement the use of this warning sign at other crossings and will also evaluate

Figure 1. View of Installed Second Train Warning Sign Looking West.

other innovative approaches to increase the level of warning for pedestrians at HRIs.

CHAPTER 1

INTRODUCTION AND STATEMENT OF PROBLEM

The Metro Blue Line (MBL) is a 22-mile light rail transit system running between downtown Los Angeles and the City of Long Beach. MBL trains, running at speeds of up to 55 miles per hour, traverse 100 grade crossings. Many of the highway-rail intersections (HRIs) are located at major streets carrying high traffic volumes. Since the startup of MBL operations in 1990, there have been numerous train/vehicle and train/pedestrian collisions at HRIs, but the accident rate has been significantly lowered as the result of a number of HRI safety improvement projects undertaken by the Los Angeles County Metropolitan Transportation Authority (LACMTA).

An important contributing factor for many train/vehicle and train/pedestrian collisions is the presence of a second train, either a slower-moving freight train or a second light rail transit (LRT) train. Often, motorists and pedestrians may be acting in a manner they thought was safe, such as avoiding slow-moving freight trains or crossing the tracks when there is an LRT train stopped at a nearby station, but their actions have resulted in collisions with second trains.

At the Vernon Avenue HRI of the MBL and adjacent freight tracks, 17 train/pedestrian collisions resulting in five fatalities have occurred since the MBL commenced revenue operations in 1990. This makes it one of the most hazardous sites on the line. As a result of its accident history and because its configuration is similar in many respects to a number of other HRIs on the MBL, the Vernon Avenue HRI was selected as the location for a demonstration project.

The Vernon Avenue HRI includes two circumstances that result in the presence of two or more trains at the same time and that are considered to be especially hazardous. First, the Vernon Avenue MBL station is located immediately to the south of the HRI, between the normally northbound (NB) and normally southbound (SB) LRT tracks. For NB LRT trains, the train operator activates the flashing lights and automatic gates at the Vernon Avenue HRI from the train cab. Consequently, NB LRT trains may be observed at the station platform with and without the automatic gates activated. If the train operator has called the automatic gates down or if there is a second train in the vicinity, it will be observed that the automatic gates have been activated while the LRT train is berthed at the station platform. Pedestrians, seeing that the automatic gates have been activated, may believe that the automatic gates have been called down by the train operator when, in fact, there is a second train in the vicinity that has caused the activation of the automatic gates.

The second circumstance at the Vernon Avenue HRI that can result in the presence of two trains at the same time is the presence of one or more freight trains at the HRI or in the vicinity of the HRI at the same time as an LRT train. This case occurs at many MBL HRIs where the MBL operates on tracks that are parallel to the Union Pacific Railroad (UPRR) freight railroad tracks. This circumstance is also especially hazardous because pedestrians observing the activation of the automatic gates may only see the slow-moving freight train approaching the HRI. In their haste to cross the tracks, they may fail to observe the LRT train approaching the HRI from the opposite direction at 55 miles per hour.

OBJECTIVE

The objective of this demonstration project was to identify and demonstrate an active warning sign that would increase the awareness of pedestrians at times when there are two trains at the same time at or in the vicinity of an HRI. The demonstration project included the observation and measurement of pedestrian behavior before and after the installation of the active warning sign to determine the sign's effectiveness and potential for reducing collisions between trains and pedestrians at HRIs. The data collection and analysis were directed to test the LACMTA's hypothesis that the warning sign system would enhance pedestrian safety by reducing the incidence of risky behavior by pedestrians when crossing the tracks when there were two trains at the same time at or in the immediate vicinity of the Vernon Avenue HRI.

DEFINITION OF THE PROBLEM

Often pedestrians may act in a manner that they think is safe, such as crossing the tracks when there is an LRT train stopped in a station or when an approaching LRT or UPRR train is observed at a considerable distance from the crossing. However, in each of these cases, pedestrians may not realize that there are two trains in the vicinity at the same time and that a second LRT train is approaching from the opposite direction.

The problem that the MBL demonstration project was designed to address concerns how to alert pedestrians and direct their attention to a second train that is approaching the grade crossing from the opposite direction. There have been 105 train/pedestrian accidents, resulting in 34 fatalities, at HRIs along the MBL since 1990.

DEMONSTRATION PROJECT SITE SELECTION

The demonstration project was conducted at the Vernon Avenue HRI in the City of Los Angeles, one of the MBL's most hazardous HRIs. The demonstration project was car-

Figure 2. View of Vernon Avenue Highway-Railroad Intersection.

ried out on the south side sidewalk at the Vernon Avenue crossing of the MBL and adjacent freight railroad tracks owned and maintained by the UPRR. The sidewalk crosses two LRT tracks, one normally NB and one normally SB, and two UPRR freight tracks. The entrance to the Vernon Avenue station is located between the normally NB and normally SB LRT tracks. See Figure 2.

Pedestrian traffic is very high at the Vernon Avenue HRI, particularly during the morning and evening peak travel hours. There are four major pedestrian traffic generators in the immediate vicinity of the HRI:

- Vernon Avenue MBL station
- LACMTA bus stop in the northeast corner of the Long Beach Avenue East and Vernon Avenue intersection
- LACMTA bus stop in the southwest corner of the Long Beach Avenue West and Vernon Avenue intersection
- Small shopping center at the northeast corner of Long Beach Avenue East and Vernon Avenue

There are much higher pedestrian volumes on the south side pedestrian crossing through the track area than for the crossing on the north side due, for the most part, to the location of the Vernon Avenue MBL station. Pedestrian counts, made by the LACMTA in March 1994, indicated that approximately 1,562 pedestrians, on the average, crossed the MBL tracks using the south side sidewalk each weekday. See Figure 3.

LACMTA passenger boarding and alighting data for the Vernon Avenue MBL station indicates that approximately 1,200 passengers board and alight from the MBL trains on an average weekday. There are approximately 220 LRT trains and 16 freight trains operated through the HRI on weekdays.

Table 1 provides a summary of the train-related collisions at the Vernon Avenue HRI, all of which have been

Figure 3. View of Vernon Avenue Highway-Railroad Intersection.

train/pedestrian collisions. There have been 17 train/pedestrian collisions at the Vernon Avenue HRI from July 1990 through September 30, 2001. Five of the collisions have resulted in fatalities, although one of the fatalities was determined to be a suicide.

CHAPTER 2

LACMTA PROPOSED SOLUTION METHODOLOGY

To meet the objective of this demonstration project, it was determined that the following tasks must be accomplished:

- Selecting sign size, message, and display type
- Sign selection pedestrian survey
- Sign and installation design
- Sign installation
- Before and after collection and analysis of pedestrian risky behavior data, as follows:
  1. Pre-installation data
  2. Post-installation data
  3. Pedestrian survey
  4. Analysis of sign effectiveness

SELECTING SIGN SIZE, MESSAGE, AND DISPLAY TYPE

A two-step procedure was used to select a second train warning sign to be demonstrated at the Vernon Avenue crossing. First, an expert panel of transportation safety specialists was convened to identify possible pedestrian-oriented second train warning signs and to identify 4–6 signs that could be used for further field testing. The expert panel

TABLE 1 Summary of Collisions at Vernon Avenue Highway-Railroad Intersection

Type of Accident	Date	Time	Reported Fatalities
Train/Pedestrian	11/07/90	0805P	1
Train/Pedestrian	03/15/92	0622A	0
Train/Pedestrian	05/11/92	1259P	0
Train/Pedestrian	10/09/92	0413P	0
Train/Pedestrian	04/12/93	0358P	0
Train/Pedestrian	08/15/93	0818P	1 (Suicide)
Train/Pedestrian	10/08/93	0331P	0
Train/Pedestrian	11/25/94	0551P	1
Train/Pedestrian	04/06/96	0758P	0
Train/Pedestrian	05/19/97	0440P	0
Train/Pedestrian	05/07/98	1030A	1
Train/Pedestrian	12/30/98	0545P	0
Train/Pedestrian	08/23/99	0729A	0
Train/Pedestrian	11/11/99	0305P	0
Train/Pedestrian	06/13/00	0722P	0
Train/Pedestrian	08/07/00	0157P	0
Train/Pedestrian	07/19/01	0510P	1

NOTE: The second train warning sign was installed on June 9, 2000.

selected four signs, two with a graphic message and two with a text message. The second step of the two-step procedure to select a warning sign involved a pedestrian interview survey conducted at the Vernon Avenue HRI.

The expert panel included representatives from the City of Los Angeles Department of Transportation (LADOT); the LACMTA Safety and Rail Operations Departments; the LACMTA's project consultant team, PB Farradyne (PBF), a Division of Parsons Brinckerhoff Quade & Douglas, Inc.; and two specialty subcontractors, Korve Engineering and Hoy Richards & Associates. The PBF consultant team was contracted for through the Engineering Management Consultant (EMC) joint venture, under its contract with the LACMTA.

The four signs selected by the expert panel were as follows.

Text Sign 1

The first text sign consisted of a static message, CAUTION SECOND TRAIN APPROACHING, activated when two trains were at or in the vicinity of the Vernon Avenue HRI. The sign is depicted in Figure 4.

Text Sign 2

The second text sign consisted of a static message, CAUTION ANOTHER TRAIN APPROACHING, activated when two trains were at or in the vicinity of the Vernon Avenue HRI. This wording was selected for further testing because of the possibility of up to four trains at the same

Figure 4. Text Sign 1.

Figure 5. Text Sign 2.

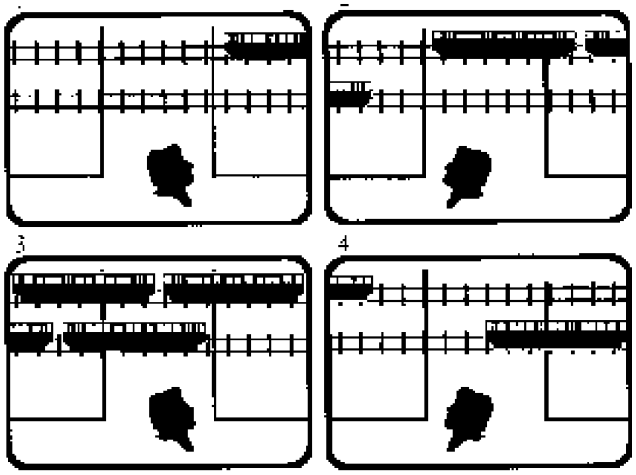


Figure 6. Graphic Sign 1.

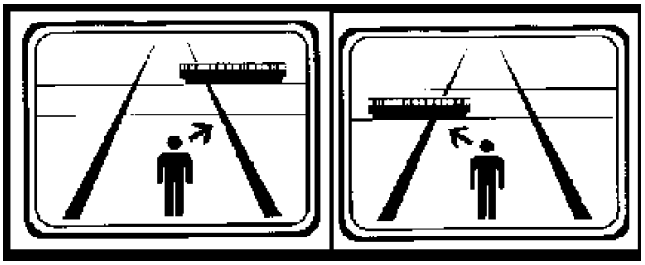


Figure 7. Graphic Sign 2.

time at the Vernon Avenue HRI. The second text sign is shown in Figure 5.

Graphic Sign 1

The first graphic sign selected for further consideration by the expert panel consisted of an animation, incorporating motion by both two LRT vehicles and a pedestrian turning head. The LRT vehicles, one from the right and then one from the left, were displayed in continuous motion after the sign was activated. The pedestrian turning head was also displayed in continuous motion, looking to the right and then to the left. See Figure 6.

Graphic Sign 2

This sign showed a two-part display, with the sign alternating between the two displays when activated by the presence of two trains at the same time. The first display showed an LRT vehicle on the top track and located to the right hand side of the display, with an arrow pointing from a pedestrian standing in front of the two tracks towards the LRT vehicle. The second display showed an LRT vehicle on the lower track and located to the left hand side of the display, with an arrow pointing from a pedestrian standing in front of the two tracks towards the LRT vehicle. See Figure 7.

SIGN SELECTION PEDESTRIAN SURVEY

As already noted, the second step in selecting the sign for evaluation consisted of interviews with approximately 400 pedestrians at the Vernon Avenue HRI, regarding their understanding of and preference for one of the four second train warning signs identified by the expert panel. Applied Management & Planning Group (AMPG) conducted the interviews in May 1997 under a subcontract with EMC.

AMPG developed the intercept survey instrument, included in Attachment C on page 37. A total of 429 completed surveys were collected, of which 246 were conducted in Spanish and 183 were conducted in English. The fieldwork was performed from May 27 to May 30, 1997, during morning and afternoon peak periods and mid-day hours.

The survey results indicated that the majority of the surveyed pedestrians were daily riders of the MBL. Also, most of the pedestrians interviewed were frequent users of the crossing. About one-half of the respondents crossed the tracks at Vernon Avenue two or more times per day (51 percent), followed by another one-quarter (24 percent) that crossed the tracks only one time per day.

The individuals interviewed also included a large number of bus riders. Seventy-two percent reported that they transferred to or from a bus at the intersection of Vernon Avenue and Long Beach Avenue.

Graphic Signs 1 and 2 were presented to the respondents before the Text Signs 1 and 2 to determine whether these signs reminded them to look both ways for more than one train. Graphic Signs 1 and 2 were shown to survey participants in random order to eliminate the bias that could result from the order of presenting signs. For Graphic Sign 1, survey participants were shown the four-part display depicted in Figure 6 and the proposed animation of the two trains and pedestrian turning head was described. For Graphic Sign 2, survey participants were told that the sign consisted of two alternating displays. First, an arrow pointed right while a train was approaching from the right; second, an arrow pointed left at a train approaching from the left.

Without any prompting for Graphic Sign 1, approximately 27 percent of the respondents thought that it reminded them to look both ways, for one or more trains, before crossing the tracks. Two-fifths (41 percent) of the respondents thought that the sign informed them that they should not cross the tracks because a train is coming. A significant number of the respondents (20 percent) didn't understand at all what message the sign was conveying to them.

When probed further by the surveyor, 89 percent said that Graphic Sign 1 reminded them to stop and look both ways before crossing the tracks, and another 89 percent reported that Graphic Sign 1 reminded them to stop and look for more than one train before crossing the tracks.

Without any prompting for Graphic Sign 2, about one-third (34 percent) of the survey respondents thought the sign indicated that they should look both ways, or look for one or

more trains before crossing the tracks. Nearly half (48 percent) of the respondents reported that the sign reminded them to stop because a train is coming. Another one-third (32 percent) thought that they were supposed to look both ways for trains before crossing the tracks. Fourteen percent indicated that they did not understand at all what message was intended from the warning sign.

Again, when probed by the surveyor, the overwhelming majority (92 percent) of the survey respondents indicated that Graphic Sign 2 would remind them to stop and look both ways before crossing the tracks, while slightly fewer respondents (90 percent) indicated that the sign reminded them to stop and look for more than one train before crossing the tracks.

In addition to the two graphic signs, the two text signs were shown to the survey respondents. Respondents were asked to identify which sign would be the most effective in reminding them to stop and look for more than one train before entering the crossing. Overall, the respondents preferred graphic signs (58 percent) to text signs (38 percent). Additionally, Graphic Sign 2 (33 percent) was preferred by survey respondents over Graphic Sign 1 (25 percent).

The overwhelming majority of the survey respondents felt that the warning sign they preferred would improve safety at the Vernon Avenue crossing, either to a great extent (62 percent) or to some extent (32 percent).

Based on the pedestrian survey results, it was determined to proceed with the fabrication and installation of the preferred Graphic Sign 2 at the Vernon Avenue HRI for testing and evaluation.

SIGN AND INSTALLATION DESIGN

A Technical Specification for the Second Train Warning Sign was prepared by Korve Engineering under a subcontract with EMC. The Technical Specification is attached on page 18 as Attachment A.

The warning sign was designed as two-sided, three feet by four feet in size, and using fiber optic bundles and quartz halogen lamps with yellow filters to internally illuminate the sign images and left/right movement of the LRT vehicles and arrows. The sign background is black and not illuminated, resulting in a yellow warning message displayed against a black background.

It was required that the fiber optic bundles be arranged so that all adjacent light points are handled by different light sources. In the event of failure of one light source, the other light source continues to provide full power to the alternate light points in order to display degraded but discernible images.

The warning sign remains dark until it is energized by power applied through an external contact closure made when two trains are approaching the crossing at the same time. Once energized, the sign then alternately displays the left train/left arrow and the right train/right arrow in flashing mode at a user-specified frequency until the power is removed.

The warning sign is activated only when two or more trains are approaching the crossing, either two MBL trains, an MBL train and a freight train, or two MBL trains and a freight train. The presence of a northbound LRT train at the Vernon Avenue station is considered to be a train approaching the crossing, even if the train operator has not called the automatic gates down. Connections to the existing track circuit and train control circuits were designed to implement the logic required to identify two trains at the same time. See Table 2 for a breakdown of two-train combinations activating the second train warning sign.

The presence of only two freight trains at the same time was not included in the warning sign control logic. The signal provided by the UPRR to the MBL train control system does not distinguish between one and two freight trains approaching the crossing. Because the system cannot determine when there are two freight trains at the crossing, this situation could not be included in the logic applied for the demonstration project.

Mounting brackets were designed so that the warning sign could be hung from a standard California Public Utilities Commission (CPUC) Number 8 flashing light assembly mast, with the sign oriented parallel to the tracks and facing pedestrians as they approached the track area. The mounting bracket configuration consisted of two 4-inch-diameter, horizontal mast arms, one along the upper edge of the warning sign and the other along the lower edge of the warning sign, together with a diagonal arm attached to the outer end of the upper horizontal mast arm. In order to support the increased sign loading, the foundation for the CPUC Number 8 flashing light assembly was set in concrete.

SIGN INSTALLATION

Installation of the warning sign was done under LACMTA Contract C0360, Metro Blue Line Grade Crossing Improvements. The warning sign was installed and made operational in June 2000. See Figures 8 and 9.

PEDESTRIAN BEFORE AND AFTER DATA COLLECTION

A video camera was installed in the southwest corner of Vernon Avenue and Long Beach Avenue West. The existing traffic signal pole at this location was replaced with a tall traffic signal pole that provides for mounting of the camera unit at the top of the pole. This location has provided a clear view of the track area for video observation and data collection.

Near the base of the traffic signal pole, a pedestal-type traffic cabinet was installed to house the camera control equipment as well as video cassette recording (VCR) equip-

TABLE 2 Two-Train Combinations Activating Second Train Warning Sign

SB LRT Occupying Track 2 Approach Circuit – Gates Called Down	NB LRT At Vernon Avenue Station – Gates Not Called Down (a)	NB LRT Occupying Track 1 Approach Circuit – Gates Called Down	UPRR Occupying First Track Approach Circuit – Gates Called Down	UPRR Occupying Second Track Approach Circuit – Gates Called Down
•	•			
•		•		
•			•	
•				•
•			•	•
	•		•	
	•			•
	•		•	•
		•	•	
		•		•
		•	•	•
•	•		•	
•	•			•
•		•	•	
•		•		•
•	•		•	•
•		•	•	•

NOTE: (a) The Vernon Avenue Station is a "near side" station, meaning that there is an HRI immediately downstream of the station. At near side stations on the MBL, the automatic gates at the downstream HRI are activated by the train operator through the use of train-to-wayside communications (TWC) and not automatically activated when the LRT train is occupying an approach track circuit.

Figure 8. View of Installed Second Train Warning Sign and Northbound LRT Train.

Figure 9. View of Installed Second Train Warning Sign and Southbound LRT Train.

ment. Video data showing pedestrian behavior at the Vernon Avenue pedestrian crossing was recorded for analysis using the VCR equipment. Conductors were run to the traffic signal cabinet from the nearby train control and communications building to provide a contact closure for two trains at the same time.

Risky behavior data was recorded on VHS video cassettes. Because each cassette was limited to two hours of recording time, cassettes were typically replaced two times per week so that continuous or nearly continuous video data was captured for instances of two trains at the same time.

Subsequently, the collected video data was observed and analyzed by a traffic engineer, who was trained to understand the project. Training and consistency were two important factors in the data collection in order to derive meaningful and accurate results. See Figure 10.

Figure 10. Video Camera Installed at Vernon Avenue.

PUBLIC INFORMATION PROGRAM

As part of the demonstration project, a four-part public information program was developed and carried out by the LACMTA Public Affairs Department in conjunction with the installation and operation of the second train warning sign. The public information program consisted of the following four communication components:

- Distribution of Flyers. The flyer distribution consisted of a one-sheet bilingual announcement explaining to the public the project and expected time window for the installation and start of operation. The flyers included a photograph of the sign and an explanation regarding the purpose of the sign. Flyers were distributed within a 10-block area around the Vernon Avenue MBL station, including distribution to local businesses and residents. "Take-One" cards containing similar information were placed on buses operating along LACMTA lines 56, 105, and 576 and on LADOT DASH buses that provide service to the Vernon Station. "Take One" cards were also placed on MBL trains.
- Signs. The posted signage consisted of poster-size bilingual announcements, with the same information contained in the flyers, placed in strategic locations at or in the immediate vicinity of the Vernon Avenue station.
- Media Event. The LACMTA Public Affairs Department worked with the LACMTA Media Relations Departments to conduct a major media event after the sign was operational. Local television, radio, and print media representatives attended the event, where invited elected officials addressed the media on the hazards of two trains at the same time and on the planned operation of the warning sign.
- Safety Education. The LACMTA Public Affairs Department described the demonstration project and how the warning sign works at all community safety fairs, tours, and school train safety assemblies conducted in the neighborhoods surrounding Vernon Avenue station.

Note that the public information program was limited and was not designed as a "two trains at the same time" safety awareness program. The public information program was focused at the Vernon Avenue station area, as described above, and was not carried out elsewhere in the system. The effect of the public information program on pedestrian behavior during the demonstration program was not measured; however, due to the focused nature of the program, it is believed by LACMTA safety engineers that any effect was minimal.

DEMONSTRATION PROJECT COSTS

Demonstration project costs are summarized in Table 3.

CHAPTER 3

ANALYSIS OF COLLECTED DATA

To view and record pedestrian behavior when two trains were at or in the vicinity of the Vernon Avenue HRI, a video camera was installed at a height of approximately 45 feet in the southwest corner of the Vernon Avenue and Long Beach Avenue West intersection. Video data was recorded and analyzed for the following time periods:

- Before warning sign installation and operation: March 24–June 9, 2000
- After warning sign installation and operation:
  a. June 9–10, 2000 (less than 24 hours, not used for evaluation; sign switch failed)
  b. July 30–September 5, 2000 (MTA operators on strike until October 20, 2000)
  c. October 20–21, 2000 (less than 24 hours, not used for evaluation; camera failed)
  d. May 20–June 18, 2001

TABLE 3 Summary of Demonstration Project Costs

Project Cost Item	Supplier	Approximate Cost
Second Train Warning Sign	National Sign	$15,000
Second Train Warning Sign Installation Including Track Circuit Modifications and CCTV Camera Equipment	LACMTA Contract C0360 Contractor (Mass Electric Corporation)	$80,000
Project Management and Engineering	PB Farradyne (*)	$ 35,000
Project Evaluation	PB Farradyne (*)	$ 70,000

NOTE: (*) Under work order from Engineering Management Consultant (EMC). Subconsultants included Korve Engineering, Hoy Richards & Associates, and Applied Management & Planning Group.

For both before and after data collection, a total of 1,470 two-train events were observed (the same number for both the "pre-installation" and "post-installation" time periods). This number was established during the before data collection time period as the number of two-train events required to observe approximately 400 pedestrians crossing the tracks when there were two trains at the same time. The sample size was based on collecting as much data as possible for the available demonstration project budget. A total of 380 pedestrians were observed crossing the tracks during the before data collection time period, an average of one every 3.9 two-train events, and a total of 326 pedestrians were observed during the after data collection time period, an average of one every 4.5 two-train events.

On the average, there were about 25 two-train events per day at the Vernon Avenue crossing during both the before and after data collection periods.

Generally, there were significantly fewer pedestrians observed to be crossing the tracks when there were two trains at the same time than was expected when the demonstration project was started.

The following data was observed for each two-train event recorded during the data collection periods:

- Time of day
- Type of two-train event (e.g. NB LRT followed by SB LRT; UPRR followed by NB LRT)
- Number of seconds in front of an approaching LRT train that a pedestrian crosses the LRT tracks (only recorded for analysis if the number of seconds is less than 15)
- Direction that pedestrians are walking, eastbound or westbound

MEASURES OF EFFECTIVENESS

The recorded video data was analyzed to determine risky behavior by pedestrians, specifically risky behavior where pedestrians crossed the LRT tracks at less than 15 seconds in front of an approaching train when there were two trains at the same time. The number of risky crossings was counted and recorded, including the number of seconds that the pedestrian crosses the track before the train arrives at the crossing. Only pedestrians crossing the tracks at less than 15 seconds in front of a train were counted. No data was collected for pedestrians crossing the tracks at 15 seconds or longer in front of an approaching train. From this data, two measures were calculated as measures of risky behavior by pedestrians:

- Number of pedestrians crossing the tracks at less than 15 seconds in front of an approaching LRT train
- Number of pedestrians crossing the tracks at six seconds or less in front of an approaching LRT train

These measures were determined on the basis of the experience and best judgment of the researchers. There is no generally accepted threshold or standard related to the number of seconds that constitutes risky behavior by pedestrians.

Arguably, the first measure is not an especially good indicator of risky behavior because 15 seconds is a relatively long advance warning time. However, the measure does indicate the number of pedestrians who disregard the flashing lights and bell warnings at the crossing. At the Vernon Avenue HRI, the flashing lights and bells are activated as soon as the XR relay drops, about 40 seconds in advance of SB LRT trains for trains running at their typical operating speeds, about 20–24 seconds in advance of NB LRT trains pulling out of the station, and about 35 seconds in advance of UPRR trains. The UPRR uses constant warning time equipment to activate the XR relay at the crossing. Typically, the train horns are sounded about 10 seconds before the train enters the crossing.

The threshold adopted for the second measure, six seconds, roughly corresponds with the time required for an LRT train to stop under emergency braking at the approach speeds of the SB LRT trains.

Comparisons were made for both measures and for the distribution of pedestrian crossing times before and after the installation of the warning sign. A significant difference between the before and after conditions according to the measures, particularly a reduction in the rate of pedestrians cross-

TABLE 4 Two-Train Events by Type and Time of Day

	Before 6:00am	6 - 9:30am	9:30 - 3pm	3 - 6:30pm	After 6:30pm	TOTAL
UPRR then NB LRT	17	56	115	68	59	315
UPRR then SB LRT	15	59	94	60	51	279
NB LRT then SB LRT	26	130	47	88	41	332
SB LRT then NB LRT	29	177	127	149	62	544
TOTAL	87	422	383	365	213	1,470

TABLE 5 Breakdown of Pedestrian Risky Crossing Times by Track

Number of Seconds	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
Track 1 – Normally NB	0	3	0	5	10	7	3	25	4	14	13	11	6	8	109
Track 2 – Normally SB	0	0	3	4	14	13	15	10	16	37	29	53	32	45	271
TOTAL	0	3	3	9	24	20	18	35	20	51	42	64	38	53	380

ing at six seconds or less in front of an approaching train, will indicate the effectiveness of the second train warning sign and success of the demonstration project.

No data on risky crossings by pedestrians was collected at other crossings during the before and after installation data collection periods.

Pedestrian awareness of the second train warning sign as well as opinions regarding the effectiveness of the second train warning sign were also measured by interview surveys with pedestrians at the Vernon Avenue station area. Positive responses from the interviewed pedestrians will indicate the effectiveness of the second train warning sign and success of the demonstration project.

BEFORE INSTALLATION DATA ANALYSIS

The before installation data analysis was performed on 19 tapes and was completed on June 9, 2000, before the second train warning sign was installed. The second train warning sign was installed on the morning of June 9, 2000.

Table 4 shows the number of two-train events recorded during different times of day for different combinations or variations of two trains at the same time. As already noted, a total of 1,470 two-train events was observed in the before data collection time period. Figure 11 shows the same data presented in Table 4 but shows the data as a bar chart for each time period. Note that the incidence of two trains at the same time is highest during the peak periods, and somewhat higher during the AM peak period than during the PM peak period.

A total of 380 pedestrians were observed crossing the LRT tracks at less than 15 seconds in front of an approaching LRT train. Table 5 summarizes the breakdown of pedestrian crossing times, less than 15 seconds, for each train direction. Figure 12 shows the same data in a graphic format.

The findings demonstrate that pedestrians, in some cases, cross the tracks without any attention to the second train. On 59 occasions, pedestrians were observed crossing the tracks at six seconds or less before an LRT train entered the crossing. On 15 occasions, pedestrians crossed the tracks at four seconds or less in front of an approaching train. On the other hand, 248 of the pedestrians observed crossing the LRT tracks were recorded at between 10 and 14 seconds prior to the train entering the crossing; this behavior is illegal and unsafe, but arguably not as risky as for the shorter crossing times.

There is a noticeable spike at eight seconds for NB risky crossings. One group of seven pedestrians crossing at the same time is included in this category.

About 71 percent of the risky pedestrian crossings were observed for the normally southbound track, track 2. It should be noted that the approach times on this approach to

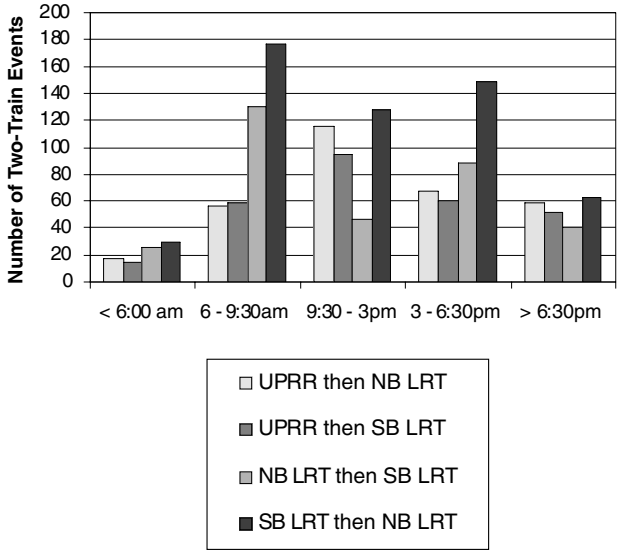


Figure 11. Two-Train Events by Time of Day Before Installation.

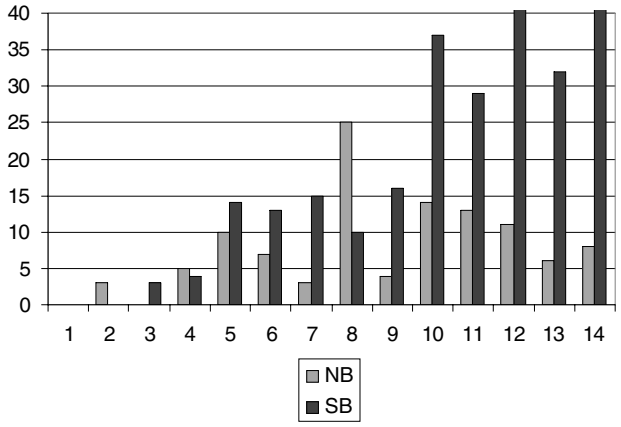


Figure 12. Breakdown of Pedestrian Risky Crossing Times Before Installation.

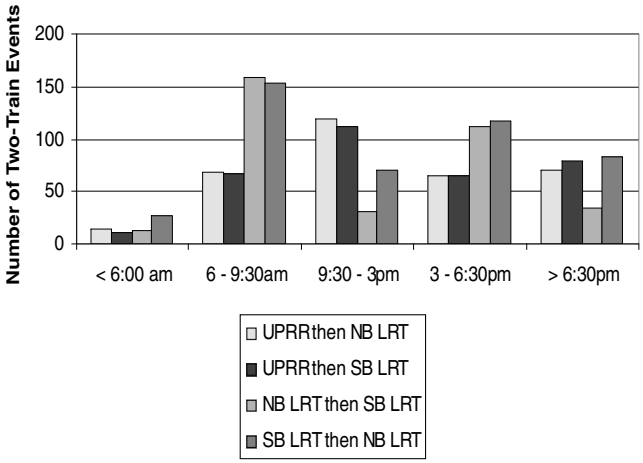


Figure 13. Two-Train Events by Type and Time of Day After Installation.

the crossing are in excess of 40 seconds as the result of a slow order, meaning that pedestrians have extended warning time to observe the approaching southbound trains before entering the track area.

The number of pedestrians crossing the tracks at six seconds or less in front of an approaching LRT train was analyzed by type of two-train event. Table 6 summarizes the results of this analysis for the before installation time period. Risky crossings of this type by pedestrians occurred most frequently where the first train was an NB LRT and the second train was an SB LRT, confirming LACMTA safety engineers' belief that the combination is particularly hazardous.

AFTER INSTALLATION DATA ANALYSIS

Analysis was performed for eight videotapes recorded from July 30 to September 5, 2000. In order to have the same number of two-train events for comparison, additional video data was collected for the period of May 20 through June 18, 2001. Therefore, the total number of recorded two-train events was 1,470, the same number of recorded events as for the "before installation" time period.

Table 7 shows the number of two-train events recorded during different times of day for different combinations or variations of two trains at the same time. As already noted, a total of 1,470 two-train events were observed in the after data collection time period. The same data is depicted graphically in Figure 13. The breakdown is remarkably the same as recorded for the before installation time period, with a lower number of two-train events with a NB train in the station and a somewhat higher number of two-train events involving UPRR freight trains during the mid-day hours.

TABLE 6 Pedestrians Crossing Tracks at Six Seconds or Less by Type of Two-Train Event

Type of Two-Train Event	Number of Events	Number of Pedestrian Crossings At Six Seconds Or Less	Pedestrian Crossings Per 100 Events
UPRR then NB LRT	315	6	1.9
UPRR then SB LRT	279	10	3.6
NB LRT then SB LRT	332	22	6.6
SB LRT then NB LRT	544	21	3.9
TOTAL	1,470	59	4.0

TABLE 7 Two-Train Events by Type and Time of Day After Installation

	Before 6:00am	6 - 9:30am	9:30am - 3pm	3 - 6:30pm	After 6:30pm	TOTAL
UPRR then NB LRT	14	69	119	64	71	337
UPRR then SB LRT	11	67	112	65	80	335
NB LRT then SB LRT	12	159	31	111	35	348
SB LRT then NB LRT	27	153	71	117	82	450
TOTAL	64	448	333	357	268	1,470

A total of 326 pedestrians were observed crossing the LRT tracks at less than 15 seconds in front of an approaching LRT train after the warning sign was installed. This was a reduction of 14 percent in the total number of risky pedestrian crossings. Table 8 summarizes the breakdown of pedestrian crossing times, less than 15 seconds, for each train direction. Figure 14 shows the same data graphically.

The number of pedestrians crossing the tracks at six seconds or less before an LRT train entered the crossing was reduced from 59 to 40, a reduction of about 32 percent. The number of pedestrians crossing the tracks at four seconds or less in front of an approaching train was reduced from 15 to four, a substantial 73-percent decline in this type of especially risky behavior. These reductions are the most significant findings from the demonstration project.

The number of pedestrians crossing between 10 seconds and 14 seconds in front of an approaching LRT train dropped from 248 to 189, a 24-percent change from the before installation data collection period.

Figure 15 provides a comparison of the number of pedestrian risky crossings, made at less than 15 seconds in front of an approaching train, for the before installation and after installation time periods by the type of two-train event. There is a noticeable reduction in the number of pedestrian risky crossings for instances where there are two LRT trains at the same time.

For the after installation time period, the number of pedestrians crossing the tracks at six seconds or less in front of an approaching LRT train was analyzed by type of two-train event, as was done for the before installation time period. Table 9 summarizes the results of this analysis for the after installation time period, including a comparison with the rate of pedestrian crossings at six seconds or less for the before installation time period. The comparative data shows that there was a reduction in risky crossings of this type by pedestrians for two-train events involving two LRT trains.

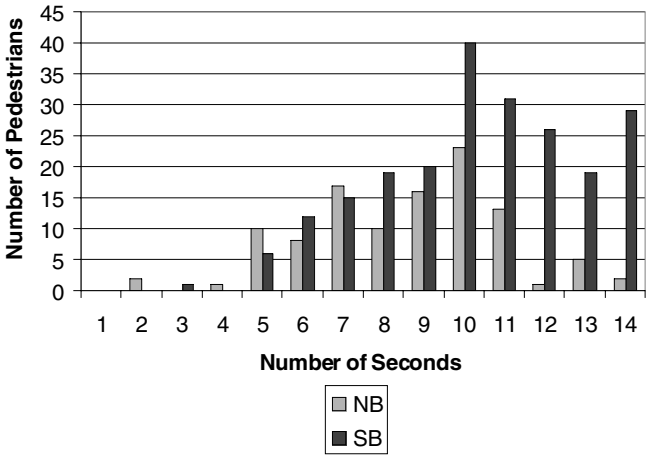


Figure 14. Breakdown of Pedestrian Risky Crossing Times After Installation.

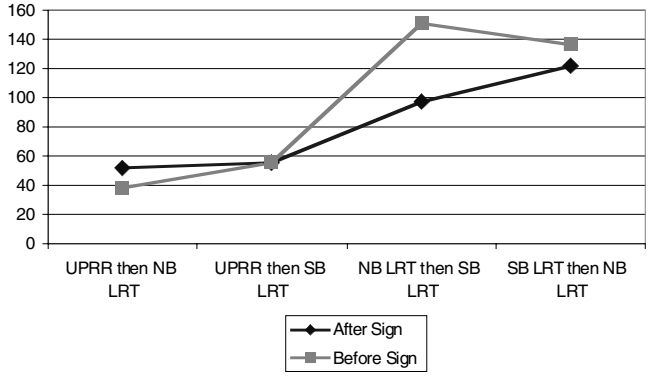


Figure 15. Comparison of Pedestrian Risky Crossings by Type of Two-Train Event.

TABLE 8 Breakdown of Pedestrian Risky Crossing Times by Track

Number of Seconds	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
Track 1 – Normally NB	0	2	0	1	10	8	17	10	16	23	13	1	5	2	108
Track 2 – Normally SB	0	0	1	0	6	12	15	19	20	40	31	26	19	29	218
TOTAL	0	2	1	1	16	20	32	29	36	63	44	27	24	31	326

TABLE 9 Pedestrians Crossing Tracks at Six Seconds or Less by Type of Two-Train Event After Installation

Type of Two-Train Event	Number of Events	Number of Pedestrian Crossings At Six Seconds Or Less	After Installation Pedestrian Crossings Per 100 Events	Before Installation Pedestrian Crossings Per 100 Events
UPRR then NB LRT	337	11	3.3	1.9
UPRR then SB LRT	335	7	2.1	3.6
NB LRT then SB LRT	348	9	2.6	6.6
SB LRT then NB LRT	450	13	2.9	3.9
TOTAL	1,470	40	2.7	4.0

In particular, the comparative data shows that the number of risky crossings of the SB LRT track after a NB LRT had traversed the crossing was reduced by about 60 percent. Overall, the comparative data shows that the number of pedestrian crossings at six seconds or less was reduced for all types of two-train events except for two-train events involving a UPRR freight train and NB LRT train. There is no explanation from the data for this increase.

WARNING SIGN EFFECTIVENESS PEDESTRIAN SURVEY

In October 2000, AMPG conducted a followup survey to measure the effectiveness of the second train warning sign since its installation through interviews with pedestrians in the Vernon Avenue station area. Surveyors interviewed 556 pedestrians at both the Vernon Avenue station platform, where passengers were waiting for their train, and at the southwest corner of Vernon Avenue and Long Beach Avenue. The primary objectives of the followup survey were to

- Gauge pedestrians' awareness of warning devices at the crossing;
- Measure pedestrians' awareness of the second train warning sign;
- Assess the extent to which pedestrians understand the warning sign; and
- Determine the extent to which pedestrians believe the warning sign improves safety at the Vernon Avenue crossing.

The survey instrument is included on page 39 as Attachment D.

Awareness of Warning Devices

Survey respondents were asked to report which warning devices served as an indication that there was a train approaching the crossing. This question was asked in the 1997 survey and was repeated for the followup survey. For the followup survey, only those respondents who indicated that they recalled the second train warning sign were asked this question.

As shown in Table 10, the bell was the most frequently mentioned warning signal in both 1997 (71 percent) and 2000 (85 percent). Awareness of all warning indicators increased since 1997, including the horn, flashing lights, the descending gate, and the traffic signal; however, this may be the result of slight differences between the 1997 and 2000 survey. A total of 18 percent of surveyed pedestrians reported that the second train warning sign provided an indication that there was a train approaching the crossing. Respondents were asked to identify all indicators of an approaching train so that multiple responses were allowed and the percentages listed exceed 100 percent.

Awareness of Second Train Warning Sign

Of the 556 pedestrians interviewed, three-quarters (77 percent) reported that they were aware of the second train warning sign. As expected, pedestrians who boarded MBL trains regularly at the Vernon Avenue station and those who crossed the tracks frequently were more likely than other pedestrians to be aware of the sign.

Just under half (49 percent) of the respondents who reported that they were aware of the sign boarded at the Vernon Avenue station two or more times a day, compared to only one-fifth of those pedestrians who could not recall the sign (21 percent), as seen in Table 11. Three-quarters of pedestrians who recalled the warning sign boarded at Vernon Avenue at least once a day (75 percent).

More than half of the pedestrians (60 percent) who were aware of the warning sign crossed the tracks two or more times per day. In contrast, only one-third (33 percent) of those pedestrians who did not recall the warning sign crossed the tracks as often. A total of 82 percent of pedestrians who could recall the warning sign crossed the tracks once per day or more. See Table 12.

TABLE 10 How Respondents Know a Train Is Coming—Comparison by Year

	1997		2000	
Warning Signals	Number*	Percent	Number*	Percent
Bell	303	71	364	85
Train Horn	102	24	304	76
Flashing Lights	138	32	204	48
Gate Descending	111	26	136	32
See Train	47	11	102	24
Second Train Warning Sign**	N/A	N/A	76	18
Traffic Signal	6	1	37	9
Refused	--	--	4	1

*Includes multiple responses.
**This category was not included in the 1997 survey.

TABLE 11 Awareness of Warning Sign by Frequency of Boarding MBL at the Vernon Station

	Aware		Not Aware	
Frequency of Boarding	**Number**	**Percent**	**Number**	**Percent**
Two or more times per day	211	49	27	21
One time per day	111	26	47	37
Two to three times per week	61	14	18	14
One time per week	25	6	10	8
Less than once per week	8	2	22	17
Not at all	12	3	4	3
Total	**428**	**100**	**128**	**100**

TABLE 12 Awareness of Warning Sign by Frequency of Crossing Tracks

	Aware		Not Aware	
Frequency of Crossings	**Number**	**Percent**	**Number**	**Percent**
Two or more times per day	252	59	41	33
One time per day	93	22	33	26
Two to three times per week	50	12	20	16
One time per week	14	3	11	9
Less than once per week	16	4	20	16
Total	**425**	**100**	**125**	**100**

TABLE 13 Respondents' Reactions to Second Train Warning Sign

Reactions to Warning Sign	Number	Percent
Train Coming	105	25
Don't Cross the Tracks	89	21
Stop/Wait	84	20
Caution/Danger	77	18
More than One Train Coming	18	4
Look both ways	13	3
Slow Down	4	1
Other	20	5
Don't know	14	3
Total	**424**	**100**

Interpretations of and Reactions to the Second Train Warning Sign

Respondents were asked both open-ended and prompted questions regarding their interpretation of the second train warning sign. Pedestrians were first asked, "What does the sign tell you?" Although only four percent of pedestrians directly related the sign to the presence of two trains, the overwhelming majority of respondents were aware that the sign indicated danger. A total of 92 percent of respondents said that they interpreted the sign in such a way that would increase their safety near the tracks either by stopping, looking both ways, or otherwise taking precautions.

Surveyed individuals' reactions to the warning sign are summarized in Table 13. Just under half of the respondents (46 percent) thought the warning sign indicated that a train was coming or that they shouldn't cross the tracks. One out of five of the respondents (20 percent) reported that the warning sign reminded them to stop.

The majority of the survey respondents felt that the warning sign improves safety at the Vernon Avenue crossing, either to a great extent (63 percent) or some extent (30 percent) as depicted in Figure 16. This finding is consistent with findings from 1997, in which 62 percent of respondents believed a second train warning sign would improve safety at the Vernon Avenue crossing to a great extent.

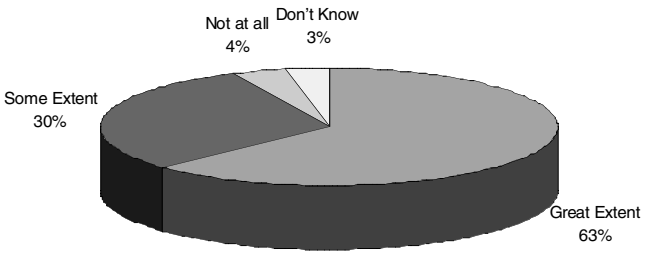


Figure 16. Extent to Which the Warning Sign Improves Safety at the Vernon Avenue Crossing Based on Pedestrian Survey Responses.

AFTER INSTALLATION ACCIDENT EXPERIENCE

Prior to the installation of the second train warning sign, there were 14 train/pedestrian accidents at the Vernon Avenue crossing during a period of ten years. It is not known how many of these accidents occurred when there were two trains in the vicinity of the crossing at the same time. After the installation of the warning sign through September 30, 2001, three train/pedestrian accidents occurred at the crossing. None of these three accidents occurred when two trains were at or in the vicinity of the crossing at the same time.

SIGN MAINTENANCE EXPERIENCE

For the 73 weeks through January 10, 2002, while the sign was operating, there was one sign malfunction. A switch failed shortly after the sign was initially installed, causing the sign to go dark until the switch was replaced. The replacement was covered under the manufacturer's warranty.

CHAPTER 4

CONCLUSIONS

The goal of installing the second train warning sign was to identify an active warning sign and conduct an assessment of its effectiveness in enhancing pedestrian safety at a busy highway-railroad intersection where there are frequently two trains at the same time at or in the vicinity of the intersection. The presence of two trains at the same time has been thought to be a potential contributing factor by LACMTA safety engineers for many train/vehicle and train/pedestrian collisions at MBL crossings. This demonstration project is viewed as an important one by the LACMTA as it seeks to identify and implement warning devices and systems that will effectively mitigate the hazard created by the presence of two trains at the same time.

The effectiveness of the second train warning sign was evaluated using two approaches. First, before and after data regarding risky crossings by pedestrians was collected and analyzed. Second, an intercept survey of pedestrians at the Vernon Avenue crossing was conducted to gauge pedestrian awareness of the second train warning sign and, more importantly, understanding of its warning message.

From the analysis of before and after data, the demonstration project found that the warning sign was effective in reducing risky behavior by pedestrians at the Vernon Avenue crossing. Overall, the number of pedestrians crossing the LRT tracks at less than 15 seconds in front of an approaching LRT train was reduced by 14 percent after the warning sign was installed.

The number of pedestrians crossing the tracks at six seconds or less before an LRT train entered the crossing was reduced from 59 to 40, a reduction of about 32 percent. Most of the reduction in risky crossings of this type was observed for two-train events involving two LRT trains, although some reduction was also noted for two-train events where one of the trains was a UPRR freight train. The number of pedestrians crossing the tracks at four seconds or less in front of an approaching LRT train was reduced from 15 to four, a substantial 73-percent decline in this type of especially risky behavior. These reductions are the most significant findings from the demonstration project, but neither finding can be shown to be statistically significant due to the small number of observations.

The intercept survey found that most pedestrians were aware of the second train warning sign and interpreted the sign as a warning sign, although only a few pedestrians interpreted the sign as meaning that there were two trains at the same time at or in the vicinity of the crossing. This is a significant finding that may question the value of graphics in conveying the desired message. LACMTA safety engineers believe that there is a learning curve associated with the recognition of any new warning sign or traffic control device and that this is the case with the graphic sign used for the demonstration project. The LACMTA has added the sign as an element of its ongoing safety education program presentations for community groups and schools.

Of the 556 pedestrians interviewed, more than three-quarters (77 percent) recalled having seen the warning sign. Only four percent of pedestrians directly related the sign to the presence of two trains, although the overwhelming majority of respondents were aware that the sign indicated danger. A total of 92 percent of respondents said they interpreted the sign in such a way that would increase their safety near the tracks either by stopping, looking both ways, or otherwise taking precautions.

The majority of intercept survey respondents (93 percent) believe that the second train warning sign improves safety at the Vernon Avenue crossing to either a great extent (63 percent) or some extent (30 percent).

Using the results of the demonstration project, the LACMTA will determine whether to implement the use of this warning sign at other crossings and will also evaluate other innovative approaches to increase the level of warning for pedestrians at HRIs.

ATTACHMENT A: SECOND TRAIN WARNING SIGN TECHNICAL SPECIFICATION

PURPOSE

This specification describes requirements for a second train warning, light emitting, fiber optic, electric sign assembly for the Los Angeles Metro Blue Line. The general design of the warning sign shall be as shown in the attached drawings. The details of construction shown in the attached drawings are typical and may be modified subject to approval by the Los Angeles County Metropolitan Transportation Authority (LACMTA). Prior to actual construction of the sign assembly, the Contractor shall submit a complete set of detailed shop drawings and a full size mockup of the sign face to LACMTA for review and approval by LACMTA.

SIGN DESCRIPTION

The sign shall be two-sided. Each sign face shall display the images of two approaching trains, a standing man, two arrows pointing to the trains, and four straight lines depicting the crosswalk and the train tracks. The images shall be internally illuminated through the use of fiber optic bundles and quartz halogen lamps with yellow filters. The sign background shall be black and not illuminated.

The sign shall remain dark until it is energized by power applied through an external contact closure made when there are two trains detected in the vicinity of the crossing at the same time. The power will be applied when two trains are approaching the crossing at the same time. Once energized, the sign shall then alternately display the left train/left arrow and the right train/right arrow in flashing mode (flash frequency and duration of alternate "on" displays to be adjustable) until the power is removed. The standing man and the track and crosswalk lines shall be displayed in steady mode at all times when the sign is energized. The flashing operation shall be controlled by an internal programmable repeat cycle timer.

The sign display shall be clearly visible with the sign images and left/right movements clearly legible at a distance of 60 feet or closer under all ambient light conditions. The unit shall be capable of continuous operation over a temperature range of -35°F to +165°F and in all weather conditions.

ENCLOSURE AND VISOR

The overall dimensions of the sign enclosure shall be approximately 36 inches high, approximately 48 inches wide, and maximum 14 inches deep. Overall weight of the assembly, including the enclosure, the visors, mounting fixtures, and all components required for the operation of the sign shall not exceed 225 pounds. The sign housing shall be constructed of extruded aluminum alloy plate of sufficient strength and shall be designed and constructed to prevent deformation or failure when subject to 70 mph wind loads. The housing may be constructed of either single thickness plate or a combination of housing frame and housing plate. Irrespective of the design, overall material thickness of the housing shall be a minimum of 0.125 inches. Corner reinforcing shall be used if necessary to maintain the integrity of the sign.

The sign face doors shall contain three over center snap (lockable) stainless steel link locks on the top and shall be connected to the housing on the bottom with a continuous full length ("piano") stainless steel hinge. The sign face doors shall contain minimum 3/32 inch thick by 3/4 inch wide neoprene door gaskets to provide a weatherproof seal. A visor shall be installed over each sign face to enhance readability. All components shall be readily accessible for maintenance from the front or back of the sign without the use of tools. The entire sign face shall be protected by a 1/8 inch anti-glare polycarbonate lens mounted into the door frames.

IMAGE DETAIL

The sign display of the images shall be as illustrated on the attached drawing. The train images and the crosswalk and train track lines shall be formed by a solid array of 0.055-inch-diameter fiber optic bundles. The arrows and the standing man images shall be outlined by 0.055-inch-diameter fiber optic bundles. Pixel points shall not be farther than 7/16 inch apart (center to center, horizontally and vertically).

The color of the images shall be yellow and shall be provided by a tempered optically correct glass color filter in conformance with the Institute of Transportation Engineers (ITE) specification. It shall be possible to change the color in the field by replacement of the supplied color filters or to replace the color filter without the removal of the sign from mounting. The images shall be displayed in white if the color filter is removed.

MOUNTING

The warning sign is intended to be hung from a 4-inch-diameter horizontal mast arm using two or more mast arm sign mounting fixtures, which shall be centrally located on the top of the housing. The warning sign shall also be affixed, along the bottom of the housing, to a second 4-inch-diameter horizontal mast arm using two or more mounting fixtures. The mounting fixtures shall be of sufficient strength and shall be designed and constructed to prevent deformation or failure when the warning sign is subjected to 70 mph

wind loads or when the lower cantilever mast is subjected to the dynamic loading of one 200-pound person swinging on the cantilever arm. The Contractor shall submit a detailed shop drawing for the proposed mounting fixtures and mounting fixture arrangement for LACMTA review and approval.

FASTENERS

A continuous full length stainless steel ("piano") hinge shall be attached along the bottom side of the housing and joined to the sign face door in such a manner as to maintain a rain tight and dust resistant seal.

Three "over center snap" (lockable) style latches shall be installed on the top side of the enclosure to hold the sign face door in the closed position and to maintain a rain tight and dust resistant seal.

ELECTRICAL REQUIREMENTS

The number of transformers and quartz halogen lamps used as the light sources for the sign shall be adequate so that the sign display is clearly visible with the sign images and left/right movements clearly legible at a distance of 60 feet or closer under all ambient light conditions.

The transformers shall have a class A insulation and shall operate the lamps. The transformers shall be impregnated with a double coating of epoxy resin or lacquer so as to preclude the intrusion of moisture. The nominal primary input voltage shall be 120 volts AC, and the secondary output shall be 10.8 volts AC under load. Connections for primary wiring shall be made via a barrier terminal strip. All wiring shall be #18 gauge stranded wire with soldered connections. All conductors shall enter the enclosure through the side, and the point of entry for the conductors shall be sealed so that it is rainproof. The lamps shall be quartz halogen, employ an MR16 socket, and be rated at 50W at 12 volts AC with a life expectancy of 8,000 hours or greater.

FIBER OPTIC BUNDLES

The images shall be formed by an arrangement of fiber optic light emitting pixel points. The fiber optic bundle transmitting the light shall be manufactured only from high quality step index glass. Plastic fiber ***CANNOT*** be used. The fiber optic bundles shall be ground smooth and optically polished at the input and output ends for maximum light transmission. At full intensity, the sign shall be visible anywhere within a 60 degree cone of vision centered about the optical axis.

The fiber optic bundles shall be mounted through the sign face from the inside.

Door panels and bundle termination holders shall be colored black to minimize reflectivity. The fiber optic bundles shall be arranged so that all adjacent light emitting pixels in the display of the images shall be fed from two distinct light sources. In the event of failure of one light source, the other shall continue to provide full power to the alternate light points thereby displaying discernible images.

DIMMER

The sign shall be equipped with a photoelectric cell mounted on the enclosure to measure the exterior ambient light intensity. The photoelectric cell shall be adjustable for sensitivity. It shall also be adjustable by rotation to avoid direct light. The photoelectric cell shall operate automatically to brighten the intensity of the sign illumination as daylight occurs and diminish the nighttime illumination to one-half of the daylight illumination as nighttime occurs.

TERMINAL BLOCK

All wiring connections in the sign assembly shall terminate on a molded, phenolic, barrier type, terminal block. Power requirements shall be 120 VAC, 5 amps maximum.

DRAWINGS

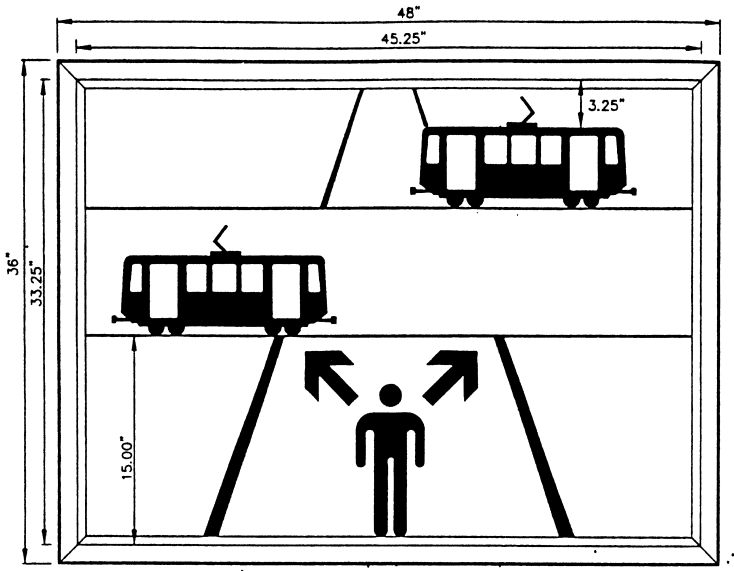
The general design of the warning sign shall be as shown in the attached drawings. The details of construction shown in the attached drawings are typical and may be modified subject to approval by the LACMTA. In the event of any discrepancy between the drawings and this specification, the specification shall be considered as the governing document.

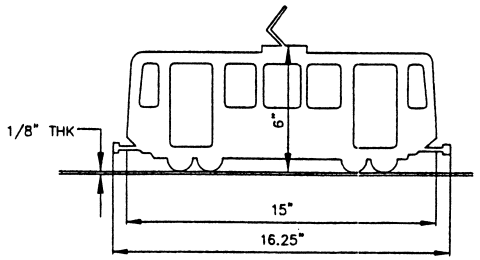
ACCEPTANCE TESTS

The LACMTA shall conduct bench and field tests to verify that the warning sign has been constructed and performs as called for in this specification.

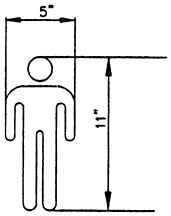
WARRANTY

The sign shall be unequivocally guaranteed for a period of one year from date that the sign meets all acceptance test requirements and is accepted by the LACMTA. In case of a failure during the warranty period, the manufacturer shall be fully responsible for all expenses involved, including shipping costs, for repair and/or replacement of the sign. Repair and/or replacement of the sign shall be done within 30 days from the date that the failure is reported to the manufacturer.

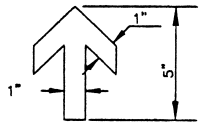




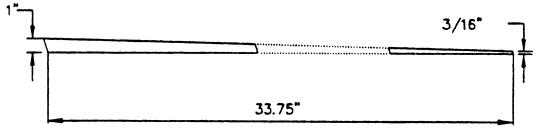
TRAIN AND TRACK IMAGE



STANDING MAN IMAGE



ARROW IMAGE



CROSS-WALK LINE IMAGE

NOTES:

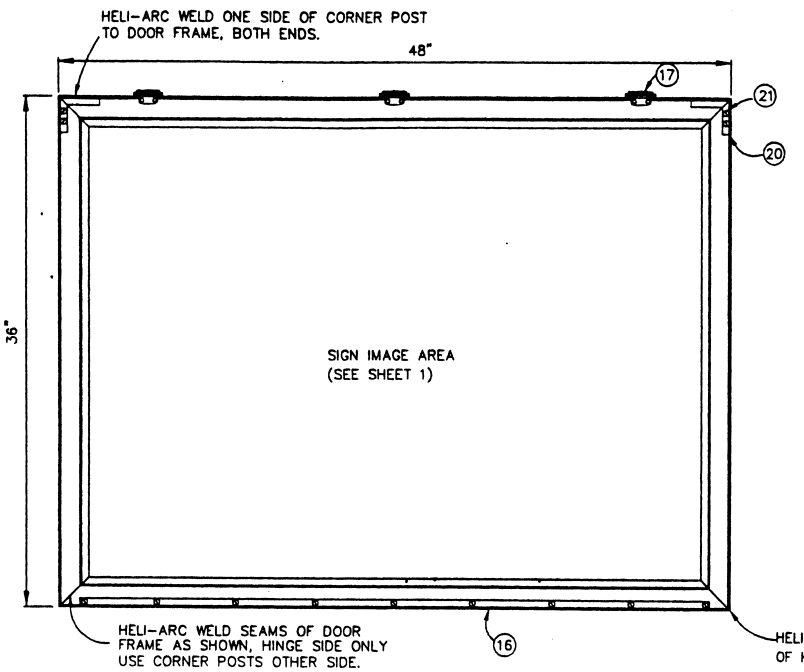
1. THE TRAIN SHALL BE SOLID FORMED BY ROWS OF FIBER OPTIC GLASS BUNDLES.
2. THE STANDING MAN AND ARROW IMAGES SHALL BE OUTLINED BY A SINGLE ROW OF FIBER OPTIC BUNDLES.
3. THE COLOR OF THE IMAGES SHALL BE YELLOW. THE SIGN BACKGROUND SHALL BE BLACK.
4. THE SIGN SHALL BE COMPLETELY BLANK OUT WHEN NOT ENERGIZED.
5. FIBER OPTIC GLASS BUNDLES SHALL ALTERNATE BETWEEN TWO OR MORE LAMP SOURCES. IN THE EVENT OF A LAMP FAILURE. THE SIGN SHALL CONTINUE TO DISPLAY READABLE AND DISCERNIBLE IMAGES.
6. SEE SHEET 2 FOR DETAILS OF THE HOUSING.

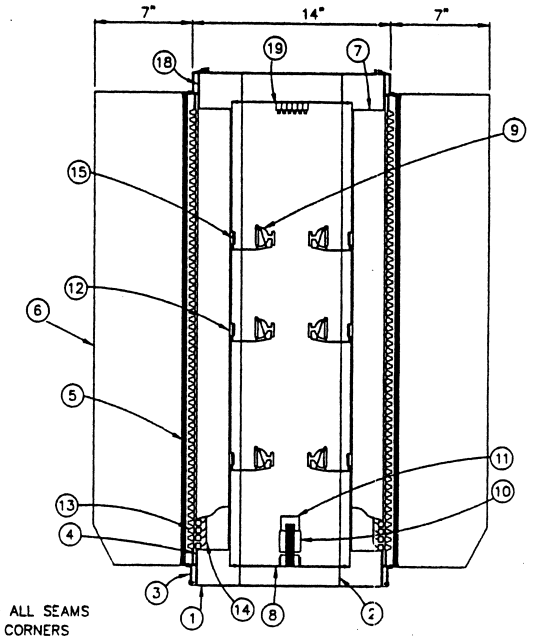
Korve Engineering

SECOND TRAIN SIGN DETAIL

SCALE: NO SCALE
DATE: 5/28/98

1 OF 2





ITEM	DESCRIPTION
1	HOUSING .063" ALUMINUM
2	HOUSING FRAME, .063" ALUMINUM
3	DOOR FRAMES, .100" EXTRUDED ALUMINUM
4	FACE PLATES, .080" ALUMINUM
5	MATTE/CLEAR POLYCARBONATE LENS, .125" THICK
6	VISOR, .063" ALUMINUM
7	OPTICS ENCLOSURES, .020" ALUMINUM
8	TRANSFORMER SHELF, .063" ALUMINUM
9	LAMPS, G.E. Q50MR16 42 W.
10	TRANSFORMERS, 120 VAC PRI., 10.8 VAC 48.5 VA SEC.
11	PROGRAMMABLE REPEAT CYCLE TIMER.
12	COMMONS (LIGHT INPUT)
13	END TIPS (LIGHT OUTPUT)
14	FIBER OPTIC GLASS BUNDLES, .055" DIA. 60° CONE OF VISION
15	GLASS COLOR FILTERS (YELLOW)
16	CONTINUOUS HINGES, 1 1/4" (OPEN) X .040 STAINLESS STEEL
17	LINK LOCK, STAINLESS STEEL
18	DOOR GASKETS, 3/32" X 3/4" NEOPRENE
19	TERMINAL STRIP
20	CORNER POST
21	#8 X 3/8" SLOTTED PAN HEAD SCREWS, STAINLESS STEEL

NOTES:
1. HOUSING AND HOUSING FRAME COMBINE TO MAINTAIN AN OVERALL THICKNESS OF .125"
2. SIGN SHALL BE EQUIPPED WITH FOUR 3/16" DIA. DRAIN HOLES LOCATED AT THE LOWER CORNERS OF THE HOUSING.
3. THE VISOR SHALL BE WEEDED TO THE FRONT DOOR FRAME.
4. HOUSING TO BE DRILLED FOR POWER AND CONTROL.
5. MOUNTING DETAIL TO BE DETERMINED BY THE MTA.
6. DOOR FRAME, FACE PLATE, AND INTERIOR OF HOUSING AND VISOR SHALL BE PAINTED FLAT BLACK NON-REFLECTIVE FINISH. EXTERIOR HOUSING COLOR TO BE DETERMINED BY THE MTA.

Korve Engineering

SECOND TRAIN SIGN DETAIL

SCALE: NO SCALE
DATE: 5/28/98

ATTACHMENT B: BEFORE AND AFTER INSTALLATION PEDESTRIAN CROSSING DATA

TAPE 1

Tape Start: 3-24-00 Friday 12:28 pm

Tape End: 3-26-00 Sunday 1:41 pm

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am				
6-9:30am	353, 357	329, 330, 354	331, 333, 334, 350, 352	332, 335, 351, 356, 361
9:30-3pm	307		308, 358, 360, 362, 364	338, 359, 363
3-6:30pm	314, 313, 315, 317, 318, 319, 320	309, 311, 312	321, 341, 343	339, 342, 344
>6:30pm	328, 349, 346	323	324, 348	325, 327, 345, 347
Pedestrians crossing the tracks less than 15 seconds prior to train coming	308 - 1@SB, 8 sec	312 - 1@NB, 13 sec	333 - 2@NB, 12 sec	325 - 1@SB, 14 sec 356 - 1@SB, 13 sec 359 - 1@SB, 9 sec

TAPE 2

Tape Start: 3-26-00 Sunday 3:07 pm

Tape End: 3-29-00 Wednesday 8:30 am

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am	442	372		
6-9:30am	406, 377, 384, 402, 403, 405, 407, 408, 409, 414, 445, 448, 450	373, 374, 376, 379, 381, 383, 401, 404, 411, 444, 446, 447, 449, 451	400, 417, 419	361, 413, 415, 416, 418
9:30-3pm	420, 424	388	421, 422, 423	385, 386, 386, 387
3-6:30pm	365, 390, 430, 434, 433, 435	431, 436	391, 426, 428, 429	366, 389, 425, 427, 432
>6:30pm	369, 370	371, 395, 437, 441	367, 368, 392, 396, 398, 399	392, 393, 394, 397
Pedestrians crossing the tracks less than 15 seconds prior to train coming	380 - 1@SB, 10 sec 402 - 1@SB, 12 sec 405 - 2@SB, 11 sec 407 - 1@NB, 5 sec 445 - 1@SB, 14 sec 448 - 2@SB, 5 sec	371 - 1@SB, 14 sec 372 - 2@SB, 12 sec 373 - 3@SB, 13 sec 374 - 3@SB, 12 sec 376 - 3@NB, 11 sec 377 - 1@SB, 12 sec 401 - 1@SB, 13 sec 404 - 2@SB, 8 sec 436 - 1@SB, 8 sec 446 - 4@SB, 9 sec 449 - 1@SB, 9 sec		386 - 2@SB, 10 sec 418 - 2@SB, 12 sec

TAPE 3

Tape Start: 3-29-00 Wednesday 8:49 am

Tape End: 3-31-00 Friday 9:10 am

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am				
6-9:30am	453, 478, 488, 520, 521, 527, 481, 487, 490, 515, 525, 526, 534	452, 477, 489, 492, 516, 519, 528, 531, 532, 533	454, 479, 482, 484, 486, 518, 523, 524, 529	480, 483, 485. 497, 517, 522, 530
9:30-3pm	460, 496, 455, 461, 462	456	457	458, 459, 494
3-6:30pm	465, 470, 504, 467, 468, 472, 506, 510	464, 466, 473, 499, 502, 503, 507, 509	501, 508	463, 500, 505
>6:30pm	513, 514	475, 476, 511, 512	469	
Pedestrians crossing the tracks less than 15 seconds prior to train coming	520 - 1@SB, 14 sec 527 - 1@SB, 6 sec 468 - 1@NB, 6 sec	464 - 3@NB, 11 sec 466 - 3@NB, 5 sec 473 - 1@NB, 11 sec 475 - 2@SB, 10 sec 502 - 1@NB, 13 sec 503 - 2@SB, 12 sec 511 - 1@SB, 12 sec 512 - 2@NB, 11 sec 516 - 2@SB, 11 sec 532 - 1@SB, 13 sec	469 - 4@NB, 12 sec	485 - 4@SB, 14 sec 500 - 2@SB, 10 sec

TAPE 4

Tape Start: 3-31-00 Friday 9:10 am

Tape End: 4-3-00 Monday 8:45 am

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am	559			
6-9:30am	563, 562	564,560		
9:30-3pm	535, 539	565	537	536, 538, 540
3-6:30pm	545, 547, 548, 550, 556	541, 542, 543, 544, 546	548, 551, 554	548, 552, 553
>6:30pm	558, 557			
Pedestrians crossing the tracks less than 15 seconds prior to train coming	560 - 4@SB, 14 sec 545 - 2@SB, 9 sec 547 - 3@NB, 4 sec 557 - 1@NB, 4 sec 562 - 2@NB, 11 sec	543 - 1@NB, 8 sec 544 - 1@SB, 6 sec 546 - 2@SB, 11 sec		

TAPE 5

Tape Start: 4-3-00 Monday 8:45 am

Tape End: 4-6-00 Thursday 2:30 pm

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am	668, 710, 669, 670, 671, 672, 674	673,709, 711, 712, 715	667, 713	666, 714
6-9:30am	644, 677, 678, 681, 722, 645, 675, 676, 717, 719, 724	641, 642, 643, 679, 680, 682, 683, 716, 718, 720, 721, 723, 726	727	725
9:30-3pm	650, 693, 728, 647	654, 684	649, 651, 653, 686, 689, 690	648, 652, 685, 687, 688, 691, 692, 729
3-6:30pm	656, 695, 705, 656, 659, 660, 661, 662, 702	655, 657, 658, 694, 696, 697, 703	698, 704	699, 700, 701, 704
>6:30pm			664, 665, 707, 708	663, 706, 707
Pedestrians crossing the tracks less than 15 seconds prior to train coming	695 - 1@SB, 7 sec 645 - 1@SB, 14 sec 659 - 1@SB, 13 sec 662 - 2@SB, 12 sec 674 - 2@SB, 12 sec 675 - 2@SB, 13 sec	643 - 1@SB, 12 sec 654 - 1@SB, 14 sec 657 - 1@NB, 8 sec 680 - 1@SB, 12 sec 694 - 2@SB, 10 sec 696 - 1@SB, 13 sec 707 - 3@NB, 2 sec 711 - 1@SB, 3 sec 716 - 1@SB, 13 sec 718 - 1@SB, 10 sec 720 - 1@SB, 6 sec 721 - 2@SB, 14 sec 723 - 5@SB, 5 sec		652 - 1@SB, 11 sec 687 - 1@SB, 6 sec

TAPE 6

Tape Start: 4-6-00 Thursday 2:30 pm

Tape End: 4-9-00 Sunday 3:15 pm

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am	756	753, 791, 806	752, 755, 812	754, 811
6-9:30am	761, 757, 758, 762, 763, 764, 765	759, 792, 794, 795	767, 813	766
9:30-3pm	731, 798,801, 814	730, 769, 804	732, 733, 771, 773, 774, 796, 799, 802	770, 800, 802
3-6:30pm	738, 776, 779, 783, 784, 815, 740, 781, 782, 803	734, 735, 736, 737, 741, 742, 775, 777, 778, 780	743, 806	743, 805, 806, 807, 808
>6:30pm	748, 749, 750, 786, 809, 810	744, 788	745, 787, 789, 790	746, 747, 751
Pedestrians crossing the tracks less than 15 seconds prior to train coming	730 - 2@SB, 3 sec 762 - 1@SB, 14 sec 764 - 1@NB, 4 sec 765 - 1@SB, 7 sec 803 - 1@NB, 10 sec 814 - 1@NB, 11 sec	742 - 1@SB, 13 sec 775 - 1@NB, 12 sec 788 - 1@SB, 10 sec 795 - 2@NB, 12 sec		743 - 2@SB, 8 sec 805 - 1@SB, 10 sec

TAPE 7

Tape Start: 4-9-00 Sunday 3:15 pm
Tape End: 4-14-00 Friday 6:50 pm

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am	826, 827	828, 906, 907, 951, 952, 953, 954	950	864, 955
6-9:30am	834, 911, 914, 919, 922, 961, 965, 829, 830, 833, 835, 865, 866, 871, 973, 912, 916, 917, 923, 927, 956, 957, 963	868, 869, 870, 872, 876, 877, 910, 913, 915, 925, 958, 964	831, 837, 838, 875, 918, 921, 924, 926, 959	832, 838, 874, 880, 960
9:30-3pm	840, 889, 891, 892, 893, 894, 897, 934,844, 849, 850, 896	846, 848, 928, 935	841, 843, 847, 886, 888, 895, 931, 932	839, 842, 845, 885, 887, 898, 929, 966, 967
3-6:30pm	855, 859, 900, 902, 904, 942, 945, 852, 860, 899, 938, 943, 944	816, 817, 818, 819, 853, 854, 856, 857, 858, 861, 941	821, 851, 898	819, 821, 898, 903
>6:30pm	823, 948, 946	822, 905	862	824, 863, 947, 949
Pedestrians crossing the tracks less than 15 seconds prior to train coming	826 - 1@SB, 10 sec 827 - 2@SB, 12 sec 835 - 1@SB, 10 sec 850 - 1@SB, 4 sec 860 - 1@SB, 11 sec 865 - 1@SB, 9 sec 927 - 2@NB, 8 sec 956 - 1@SB, 11 sec 963 - 1@NB, 11 sec	817 - 1@SB, 7 sec 828 - 1@SB, 14 sec 854 - 1@SB, 5 sec 856 - 3@SB, 12 sec 869 - 1@SB, 9 sec 870 - 1@NB, 13 sec 907 - 1@SB, 11 sec 941 - 1@SB, 11 sec	843 - 3@NB, 12 sec 895 - 2@NB, 10 sec	955 - 1@SB, 11 sec 960 - 2@SB, 14 Sec

TAPE 9

Tape Start: 4-21-00 Friday 4:44 am
Tape End: 4-22-00 Saturday 5:45 pm

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am	171	133, 173		170, 172, 175
6-9:30am	139, 140, 146, 135, 143, 145	134, 136, 137, 141, 142, 144	174	176
9:30-3pm	148, 178, 181, 150, 151	155	154, 179, 180, 182, 184, 186, 187, 189	152, 154, 156, 183, 185, 188
3-6:30pm	162, 164, 194	157, 160, 161, 163	158, 165, 191, 193	159, 190, 191, 192
>6:30pm		169	167, 168	166
Pedestrians crossing the tracks less than 15 seconds prior to train coming	150 - 1@SB, 11 sec 151 - 2@SB, 14 sec 162 - 4@SB, 13 sec	134 - 2@SB, 14 sec 136 - 1@SB, 9 sec 157 - 4@SB, 12 sec 161 - 2@SB, 10 sec	184 - 1@NB, 13 sec 193 - 1@NB, 9 sec	183 - 2@SB, 10 sec

TAPE 10

Tape Start: 4-22-00 Saturday 5:45 pm

Tape End: 4-27-00 Thursday 5:55 pm

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am		203, 227, 235	202, 205	204
6-9:30am	233, 230, 232, 237	208, 209, 234	231	206, 207, 229, 231, 236
9:30-3pm	242	213, 215, 238, 239	211, 212, 214, 217, 218, 241	210, 240
3-6:30pm	196, 245, 251, 219	246,248		
>6:30pm	201, 225		197, 199	198, 200, 224, 226
Pedestrians crossing the tracks less than 15 seconds prior to train coming	245 - 1@SB, 13 sec 251 - 1@SB, 10 sec 232 - 1@NB, 6 sec 242 - 1@NB, 8 sec	208 - 1@SB, 12 sec 234 - 1@SB, 13 sec 238 - 2@SB, 10 sec 239 - 1@SB, 10 sec 246 - 1@SB, 7 sec 248 - 2@SB, 13 sec	218 - 1@NB, 8 sec	231 - 1@SB, 13 sec 236 - 1@SB, 13 sec 240 - 1@SB, 7 sec

TAPE 11

Tape Start: 4-27-00 Thursday 5:55 pm

Tape End: 5-4-00 Thursday 9:20 am

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am				
6-9:30am	449	359, 400, 401, 448, 451	447	428, 429, 430
9:30-3pm	410, 412, 460, 458, 463, 466	402, 403, 456, 432, 434, 462, 465	411, 413, 435, 461	457, 464
3-6:30pm	390, 414, 416, 415, 416, 444, 470	468, 469	417, 443	385
>6:30pm	343, 392, 344, 419, 424, 425	348, 418, 393, 423		345
Pedestrians crossing the tracks less than 15 seconds prior to train coming	343 - 1@SB, 10sec 390 - 2@SB, 10sec 392 - 2@SB, 14sec 344 - 1@SB, 6sec 414 - 1@SB, 12sec 416 - 1@SB, 7sec 424 - 1@SB, 14sec 458 - 1@SB, 7sec	348 - 1@SB, 9sec 359 - 1@NB, 14sec 393 - 1@SB, 9sec 400 - 1@NB, 9sec 448 - 1@SB, 10sec		345 - 2@SB, 12sec 385 - 1@SB, 7sec

TAPE 12

Tape Start: 5-4-00 Thursday 9:20 am

Tape End: 5-11-00 Thursday 9:05 am

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am		507	538	
6-9:30am	508, 511, 512, 515, 510, 514, 541, 543	509, 513, 542, 559, 560	539, 540, 561	539, 540, 562
9:30-3pm	476, 483, 517, 548, 550, 567, 516, 523	481, 482, 546, 564, 565	473, 474, 475, 478, 480, 518, 520, 521, 545, 549, 566	472, 474, 519, 522, 544, 547
3-6:30pm	494, 495, 527, 529, 491, 524, 526, 552, 554	485, 488, 496, 497, 525, 531	486, 490, 492, 493, 528, 530, 553	487, 551
>6:30pm	499, 501, 506, 505, 537	502, 558	498, 500, 504, 534, 535, 556	503, 532, 536, 555, 557
Pedestrians crossing the tracks less than 15 seconds prior to train coming	494 - 1@SB, 10 sec 495 - 1@SB, 5 sec 524 - 1@NB, 10 sec 552 - 1@SB, 11 sec	481 - 2@SB, 11 sec 482 - 1@SB, 10 sec 488 - 1@SB, 12 sec 502 - 1@SB, 11 sec	549 - 2@NB, 10 sec	547 - 1@SB, 12 sec 555 - 3@SB, 12 sec 530 - 1@SB, 12 sec

TAPE 13

Tape Start: 5-11-00 Thursday 9:05 am

Tape End: 5-20-00 Saturday 10:50 am

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am		641, 720	643, 677	643
6-9:30am	697, 723, 726, 642, 648, 650, 652 698, 727, 728, 729	644, 647, 649, 651, 653, 679, 721, 722, 725, 734	645, 678, 680, 730, 732	646, 696, 731, 733
9:30-3pm	654, 661, 683, 701, 703, 616, 618, 700, 706, 735	681, 699	613, 615, 617, 656, 658, 684, 685, 702, 704, 707	614, 655, 659, 680, 705, 707
3-6:30pm	619, 623, 663, 622, 631, 632, 662, 666, 667, 668, 669, 689	620, 621, 630, 665, 670	624, 625, 627, 628, 664, 688, 708, 709, 711	626, 629, 710, 712
>6:30pm	638, 673, 675, 713, 718, 635, 674	634, 693, 695, 715, 716	639, 671, 672, 691, 692, 714, 717, 719	637, 690, 671, 694
Pedestrians crossing the tracks less than 15 seconds prior to train coming	623 - 1@SB, 6 sec 661 - 1@SB, 5 sec 701 - 6@SB, 14 sec 622 - 1@SB, 12 sec 631 - 2@NB, 7 sec 650 - 3@SB, 13 sec 668 - 7@NB, 8 sec 669 - 1@SB, 10 sec 700 - 1@SB, 14sec 728 - 1@SB, 13sec	620 - 1@SB, 9 sec 621 - 2@NB, 8 sec 647 - 1@NB, 5 sec 649 - 1@NB, 7 sec 665 - 1@SB, 14 sec	688 - 1@NB, 12 sec 709 - 1@NB, 5 sec	629 - 3@SB, 5 sec 686 - 1@SB, 11 sec 696 - 1@SB, 5 sec

TAPE 14

Tape Start: 5-20-00 Saturday 10:50 am

Tape End: 5-25-00 Thursday 8:45 am

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am	757, 758, 862		823	823
6-9:30am	777, 790, 835, 866, 868, 786, 792, 826, 827, 837, 838, 867, 870, 872	778, 779, 785, 791, 834, 836, 864, 865, 869, 871	759, 782, 784, 829, 830, 832, 874	760, 781, 783, 793, 829, 832, 863, 873, 874
9:30-3pm	748, 762, 763, 770, 771, 799, 801, 846, 746, 747, 773, 795, 878	839, 844, 847, 879	764, 765, 766, 768, 769, 772, 802, 804, 806, 841, 842, 843, 877	745, 761, 767, 796, 798, 800, 803, 806, 840, 845, 876
3-6:30pm	808, 811, 812, 813, 848, 849, 853	774, 809, 850, 852, 854, 881, 882	749, 750, 814, 851, 884	807, 810, 851, 883, 884
>6:30pm	816, 822, 755, 858	756, 860	753, 754, 775, 780, 818, 820, 824, 856, 859	753, 815, 817, 819, 821, 825, 855, 859, 861
Pedestrians crossing the tracks less than 15 seconds prior to train coming	811 - 1@SB, 8 sec 816 - 1@SB, 7 sec 795 - 2@NB, 14 sec 838 - 1@SB, 12 sec 853 - 1@SB, 8 sec 867 - 5@NB, 14 sec	774 - 2@NB, 8 sec 809 - 2@SB, 7sec 839 - 1@SB, 6 sec 854 - 1@SB, 11 sec 881 - 2@NB, 10 sec	775 - 2@SB, 10 sec	761 - 1@SB, 6 sec 803 - 1@SB, 12 sec 817 - 1@SB, 12 sec 825 - 1@SB, 11 sec 784 - 1@NB, 9 sec

TAPE 15

Tape Start: 5-25-00 Thursday 8:45 am

Tape End: 5-30-00 Tuesday 9:30 am

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am	905, 906			986, 6
6-9:30am	911, 914, 989, 15, 907, 969, 7	909, 910, 967, 968, 987, 8, 11, 12, 13, 14	988, 10	908, 912, 9, 10
9:30-3pm	891, 895, 916, 921, 923, 925, 928, 946, 952, 955, 887, 915, 942, 945, 971, 974	917, 941, 992, 993	889, 890, 893, 894, 919, 920, 922, 924, 926, 927, 929, 947, 949, 951, 953, 970, 972, 975, 991	888, 918, 922, 930, 943, 944, 948, 950, 954, 973, 976, 990
3-6:30pm	899, 900, 933, 957, 997, 898, 931, 979, 994, 995	897, 932, 934	896, 956, 958, 960, 978, 982, 999	959, 977, 980, 981, 996, 998
>6:30pm	935, 2, 5, 0	936, 939, 985, 1, 3	937, 938, 962, 963, 965, 983, 4	901, 964
Pedestrians crossing the tracks less than 15 seconds prior to train coming	895 - 1@SB, 12 sec 955 - 3@SB, 12 sec 997 - 1@SB, 14 sec 942 - 1@SB, 6 sec 995 - 1@SB, 8 sec	932 - 1@SB, 11 sec 936 - 1@SB, 11 sec 993 - 3@NB, 8 sec	926 - 1@NB, 6 sec 960 - 2@NB, 10 sec 983 - 3@NB, 8 sec	950 - 3@SB, 14sec 959 - 2@SB, 11 sec 973 - 1@SB, 12 sec 10 - 1@SB, 10 sec 896 - 1@SB, 7 sec

TAPE 16

Tape Start: 5-30-00 Tuesday 9:30 am

Tape End: 6-2-00 Friday 9:30 am

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am	42, 93, 88, 117, 118	89, 90	41	41
6-9:30am	44, 46, 53, 54, 125, 126, 49, 51, 52, 127	43, 48, 50, 94, 119, 120, 122, 123, 124, 128	45, 91, 95, 130	91, 129
9:30-3pm	59, 60, 67, 69, 72, 102, 104, 105, 55, 64, 65, 73, 101, 131	17, 56	16, 57, 61, 66, 68, 70, 103	62, 71
3-6:30pm	76, 78, 81, 110, 79, 90, 109, 111, 112, 114	77, 107	74, 106	75, 108, 113
>6:30pm	40, 82, 86	85	83	39, 87
Pedestrians crossing the tracks less than 15 seconds prior to train coming	86 - 1@SB, 10 sec 109 - 1@SB, 13sec	56 - 1@NB, 6sec 89 - 1@SB, 6sec 107 - 1@SB, 7 sec	66 - 1@NB, 8 sec 74 - 2@NB, 6 sec	41 - 1@SB, 14 sec 71 - 1@SB, 9sec 75 - 3@SB, 6 sec

TAPE 17

Tape Start: 6-2-00 Friday 7:00 pm

Tape End: 6-8-00 Thursday 12:45 pm

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am	207, 208, 252, 287, 186, 288	209	187	
6-9:30am	159, 215, 216, 221, 224, 226, 253, 254, 257, 261, 290, 211, 217, 218, 225, 255, 258, 262	188, 210, 214, 223, 256, 259, 260, 289, 291, 292	212, 213, 219	160, 212, 220, 222
9:30-3pm	161, 166, 229, 265, 163, 170, 269, 270	162, 164, 190, 192, 263	191, 195, 197, 227	165, 171, 189, 191, 193, 194, 196, 198, 228, 266, 267, 268
3-6:30pm	246, 248, 281, 203, 204, 240, 245, 273, 276, 277, 279	180, 235, 238, 239, 241, 274, 275, 278	173, 175, 177, 179, 199, 202, 236, 237, 242, 247, 271, 280	172, 174, 176, 201, 205, 237, 243, 244
>6:30pm	154, 251, 282, 283	155, 156, 157, 206, 249, 250, 286	153, 158, 185	158, 184, 284, 285
Pedestrians crossing the tracks less than 15 seconds prior to train coming	154 - 1@SB, 11 sec 163 - 1@NB, 12 sec 170 - 1@NB, 12 sec 240 - 1@SB, 13 sec 245 - 2@SB, 4sec 283 - 2@SB, 12sec	155 - 1@SB, 9 sec 156 - 1@NB, 10 sec 164 - 1@SB, 14 sec 210 - 1@SB, 8 sec 214 - 1@SB, 4 sec 249 - 2@SB, 11 sec 260 - 1@SB, 13sec 289 - 1@SB, 10sec 291 - 1@SB, 12 sec 292 - 2@SB, 12 sec	213 - 1@NB, 9 sec 236 - 2@NB, 6 sec 247 - 1@NB, 10 sec	189 - 1@SB, 10sec 212 - 1@SB, 6sec 244 - 1@SB, 14sec

TAPE 18

Tape Start: 6-8-00 Thursday 12:45 pm

Tape End: 6-12-00 Monday 8:45 am

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am	319			
6-9:30am	324	320, 321, 323, 327		
9:30-3pm		295, 299	297	296, 298
3-6:30pm	300, 303, 306, 307	301, 304, 305	308	
>6:30pm	310, 311, 312	318	315, 316, 317	314
Pedestrians crossing the tracks less than 15 seconds prior to train coming	311 - 1@NS, 8 sec	299 - 1@SB, 12 sec 305 - 2@NB, 13 sec 327 - 1@SB, 7 sec		

TAPE 22

Tape Start: 7-30-00 Sunday 7:24 pm

Tape End: 8-3-00 Thursday 5:50 am

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am	963	869, 925	926	926
6-9:30am	832, 840, 842, 881, 887, 888, 931, 932, 936	838, 839, 843, 878, 883, 884, 885, 886, 889, 928, 929, 933, 934, 937	836, 870, 872, 873, 875, 876, 877, 927	837, 871, 874, 876
9:30-3pm	844, 896	890	846, 891, 893, 898, 9000, 904, 905, 938, 940, 941	845, 847, 892, 897, 899, 901, 902, 903, 939
3-6:30pm	855, 906, 911, 912, 944, 947, 948	856, 907, 909, 910, 943, 945, 946, 949	859, 857, 942, 952	858, 857, 913, 942
>6:30pm	830, 861, 862, 863, 924	829, 860, 865, 866, 954	824, 828, 914, 917, 918, 955, 958, 959	864, 915, 916, 919, 920, 921, 923, 956, 957, 960
Pedestrians crossing the tracks less than 15 seconds prior to train coming	832 - 1@SB, 12 sec 911 - 1@SB, 10 sec	885 - 1@SB, 11 sec 886 - 1@SB, 6 sec 925 - 1@SB, 14 sec 943 - 1@SB, 13 sec 954 - 1@SB, 10 sec		837 - 1@SB, 12 sec 874 - 1@SB, 11 sec 902 - 1@SB, 8 sec 919 - 1@SB, 5 sec

TAPE 23

Tape Start: 8-7-00 Monday 5:45 pm

Tape End: 8-11-00 Friday 8:30 am

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am	13, 52	974, 51	91, 92, 93	90, 92
6-9:30am	977, 978, 979, 14, 20, 24, 53, 58	975, 980, 16, 18, 19, 21, 22, 25, 55, 59, 60		15
9:30-3pm		68	66, 67	67
3-6:30pm	75, 77, 80, 83	74	78, 82	78, 79, 81
>6:30pm		965, 984	966, 970, 972, 8, 11, 88	964, 969, 971, 973, 8, 9, 11
Pedestrians crossing the tracks less than 15 seconds prior to train coming	977 - 1@SB, 6 sec 20 - 1@SB, 9 sec 77 - 1@NB, 4 sec	975 - 1@NB, 5 sec 18 - 3@NB, 6 sec 21 - 1@NB, 10 sec		

TAPE 24

Tape Start: 8-11-00 Friday 8:30 am

Tape End: 8-15-00 Tuesday 5:30 pm

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am	194			
6-9:30am	106, 142, 195, 197, 199, 202, 205	143, 144, 171, 196	169, 200, 201, 203	170, 200, 203
9:30-3pm	113, 120, 151		116, 119, 150, 154, 160, 178, 180, 181	115, 118, 152, 155, 159, 179
3-6:30pm	127, 129	128, 130, 133, 186, 187	123, 125	123, 124, 126, 183, 184
>6:30pm	167	141, 192	137, 138, 139, 105, 166, 168, 191	136, 164, 190, 191, 193
Pedestrians crossing the tracks less than 15 seconds prior to train coming	151 - 1@SB, 13 sec	187 - 1@NB, 8 sec 135 - 1@SB, 12 sec		155 - 1@SB, 6 sec 184 - 2@SB, 9 sec

TAPE 25

Tape Start: 8-15-00 Tuesday 5:30 pm

Tape End: 8-21-00 Monday 12:30 pm

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am		264, 317		
6-9:30am	278, 319, 365, 366, 370, 372, 373, 377	277, 279, 280, 281, 361, 362, 367, 369, 374	265, 267, 268, 270, 271, 273, 274, 375	266, 269, 272, 274, 376, 383
9:30-3pm	332, 333, 334, 378, 384	339, 340, 382	292, 294, 295, 298, 299, 300, 326, 327, 336, 338, 380	287, 291, 293, 296, 297, 300, 301, 326, 327, 328, 379, 381, 383
3-6:30pm	251, 305, 345, 348, 350, 352	252, 253, 306, 308, 309, 342, 344, 346, 351	303, 349	302, 304, 349
>6:30pm		260, 261, 314	262, 263, 310, 315, 353, 357, 358, 360	310, 316, 354, 356, 359
Pedestrians crossing the tracks less than 15 seconds prior to train coming	251 - 1@SB, 10 sec 305 - 1@SB, 7 sec 366 - 1@SB, 5 sec	361 - 1@SB, 10 sec		266 - 2@SB, 14 sec 269 - 1@SB, 13 esc 272 - 1@SB, 11 sec 274 - 2@SB, 11 sec 276 - 1@SB, 7 sec 301 - 2@SB, 6 sec

TAPE 26

Tape Start: 8-21-00 Monday 12:30 pm

Tape End: 8-25-00 Friday 1:20 pm

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am	432,500			
6-9:30am	410, 411, 433, 449, 453, 454, 458, 502, 455, 457, 501, 507	405, 406, 407, 409, 444, 448, 451, 452, 456, 504, 505, 506, 508	412, 445, 446, 503	404, 412, 445, 447
9:30-3pm	416, 466, 509, 513, 414, 467	387, 389, 510	388, 418, 460, 462, 464, 465, 512	413, 417, 419, 459, 461, 463, 511
3-6:30pm	391, 396, 479, 519, 392, 393, 394, 421, 422, 481, 484, 487, 522, 523	390, 395, 424, 425, 480, 482, 483, 486, 488, 489, 514, 515, 524, 525, 526, 531	397, 423, 468, 470, 474, 475, 477, 478, 516, 520, 527, 528, 529, 530	398, 471, 473, 476, 478, 517, 518, 521
>6:30pm	400, 426, 436, 439, 440, 441, 494, 430, 431, 491	399, 428, 429, 432	401, 403, 427, 432, 433, 437, 438, 490, 492, 495, 533	401, 427, 434, 435, 493, 496, 498
Pedestrians crossing the tracks less than 15 seconds prior to train coming	414 - 1@SB, 14 sec	395 - 1@SB, 14 sec 406 - 1@SB, 8 sec 424 - 1@SB, 10 sec 451 - 3@SB, 12 sec 480 - 10@NB, 10 sec 504 - 1@SB, 9 sec 505 - 1@SB, 9 sec 532 - 1@SB, 9 sec		445 - 1@SB, 14 sec 473 - 1@SB, 6 sec 478 - 2@SB, 10 sec 518 - 2@SB, 8 sec

TAPE 27

Tape Start: 8-25-00 Friday 1:20 pm

Tape End: 8-29-00 Tuesday 8:45 am

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am				
6-9:30am	558, 592, 600, 569, 590, 594, 596, 597, 598, 599	570, 588, 589, 591, 595, 601	556, 568, 571, 593, 602	557, 567, 603
9:30-3pm	608, 559, 560	607, 609	573, 575, 577, 606	572, 574, 575, 576, 604, 605
3-6:30pm	542, 561, 562, 583, 610, 616, 618, 539, 540, 544, 545, 612, 614, 617	541, 543, 578, 611, 613, 615	537, 580, 582	535, 538, 579, 581
>6:30pm	547, 550, 554, 565, 566, 623, 625, 631, 632, 552, 555, 584, 624, 626, 628, 629, 630, 636	627, 633, 634, 635, 637, 638	548, 549, 563, 564, 585, 620, 622	551, 553, 585, 586, 587, 619, 621
Pedestrians crossing the tracks less than 15 seconds prior to train coming	542 - 2@SB, 14 sec 616 - 1@SB, 12 sec 544 - 7@SB, 10 sec 552 - 1@SB, 10 sec	543 - 1@SB, 10 sec 588 - 1@SB, 11 sec 591 - 2@SB, 10 sec 611 - 1@SB, 12 sec 637 - 1@SB, 11 sec 638 - 1@SB, 9 sec		604 - 1@SB, 12 sec

TAPE 28

Tape Start: 8-29-00 Tuesday 8:50 am

Tape End: 9-5-00 Tuesday 9:20 am

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am				
6-9:30am	678, 683, 684, 757, 681, 688, 689, 690, 692, 716, 717, 730, 754, 755	679, 680, 682, 685, 691, 694, 715, 720, 721, 722, 723, 724, 725, 726, 728, 729, 752, 753, 756	688, 693, 718, 719	686, 687, 693, 718, 719
9:30-3pm	738, 640, 731, 736, 758	642, 644, 656, 695, 759	645, 647, 649, 696, 697, 699, 733, 735, 737, 760	643, 646, 648, 650, 652, 698, 732, 734, 761, 762, 763
3-6:30pm	670, 664, 701, 739, 740, 741, 742	659, 660, 662, 663, 665, 666, 667, 669, 700	653, 655, 657, 658, 668, 744, 746	654, 658, 745
>6:30pm	673, 676, 703, 704, 711, 713, 675, 714, 750, 751	702, 747, 748	672, 706, 708, 709	671, 674, 707, 710, 749
Pedestrians crossing the tracks less than 15 seconds prior to train coming	757 - 2@SB, 8 sec 692 - 1@SB, 6 sec 716 - 3@NB, 11 sec	644 - 2@NB, 10 sec 656 - 1@NB, 9 sec 702 - 1@SB, 12 sec 715 - 2@SB, 11 sec 748 - 1@SB, 8 sec 752 - 1@SB, 14 sec 753 - 2@SB, 10 sec	746 - 2@SB, 11 sec	648 - 1@SB, 10 sec 671 - 1@SB, 14 sec 719 - 1@SB, 9 sec

TAPE 34

Tape Start: 5-20-01 Sunday

Tape End: 5-23-01 Wednesday

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am	283, 329, 234, 281	318,382		280
6-9:30am	238, 240, 283,285, 288, 336, 338,340, 344, 345, 235,243,244,245,291, 341,342	236,237,239, 241,242, 246,284,286,287,290, 292, 293, 295,335,337,339,314,343	230,232,233,234,	247, 331
9:30-3pm	250, 255, 298, 251		227, 248, 249, 252, 253, 254, 258, 308, 309, 301, 303, 305,307, 308,309	226,228,256, 257296, 297, 300, 302, 304,306
3-6:30pm	267, 231,261, 264, 267, 314, 318, 230, 263, 265, 275, 317	229, 259, 262, 266, 313, 315, 316,373,374,319	271, 232,260,311,312,320	269,270, 272,310
>6:30pm	234, 278, 279, 321,327	233	225	322,323
Pedestrians crossing the tracks less than 15 seconds prior to train coming	283-3 @ SB, 12 sec 288-1 @ SB, 7sec 288-2 @ SB, 10sec 298-2 @ SB, 10 sec 243-2 @ NB, 8 sec 251-2 @ NB, 7sec 317-1 @ SB, 11sec 251-2 @ NB, 7 sec 327-1@ SB, 13 sec	328-1 @ SB, 13 sec 328-1 @ SB, 7 sec 335-2 @ SB, 14 sec 337-1 @ SB, 9 sec 239-1 @ SB, 12 sec 274-1 @ SB, 11 sec 290-1 @ SB, 11 sec 314-1 @ SB, 13 sec 314-1 @ SB, 15 sec 315-2 @ SB, 11 sec 339-2 @ SB, 6 sec 343-1 @ SB, 11 sec	234-1 @ NB, 9 sec	226-1@ SB, 7 sec 228-1@SB, 10 sec 269-1 @ SB, 8 sec 300-2@ SB, 8 sec 302-3 @ SB 14sec

TAPE 35

Start: 5-23-01 Wed 8:30 am

End: 5-24-01 Thursday 12:40 pm

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am	370		368	
6-9:30am	373, 349, 371, 372	348, 379	360, 377, 380, 383	374, 375, 376, 378, 381, 382, 384, 385
9:30-3pm	353,355	356		351,354
3-6:30pm		357, 358, 359, 360, 362		
>6:30pm	363, 364		366	365, 367, 369
Pedestrians crossing the tracks less than 15 seconds prior to train coming	370-1 @ SB, 7 sec 370-1 @ SB, 14 sec	359-1 @ SB, 14 sec		374-1@ SB, 1 sec

TAPE 36

Tape Start: 5-24-01 Thursday

Tape End: 5-28-00 Monday

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am			475	409
6-9:30am	426, 419, 420, 422, 449, 461	410, 412, 423, 424, 462	451, 452	411, 450
9:30-3pm	463, 479	477, 476	388, 389, 391, 393, 434, 454, 464, 466	388, 390, 392, 453, 465,
3-6:30pm	395, 401, 403, 439, 458, 396, 397, 437, 443	398, 399, 400, 435, 436, 438, 440, 441, 442, 471	394, 355, 356, 357	458, 467, 468, 470, 456
>6:30pm	447, 404, 446			444, 459
Pedestrians crossing the tracks less than 15 seconds prior to train coming	403-1@ SB, 11 sec 403-1@ SB, 12 sec 463-1 @ SB, 11 sec 419 -1 @ SB, 8 sec 437-1 @ NB, 13 sec 472- 3 @ NB, 7 sec	398-2 @ SB, 13 sec 436-1 @ SB, 15 sec 477-1 @ SB, 6 sec 477-1 @ SB, 11 sec	394-3 @ NB, 8 sec 455-2 @ NB, 2 sec 456-1 @ NB, 13 sec	388-2 @ SB, 9 sec 394-2 @ SB, 7 sec 455-2@ SB, 8 sec 411-1 @ SB, 3 sec 411-1 @ SB, 15 sec

TAPE 37

Tape Start: 5-28-01 Monday

Tape End: 5-31-01 Thursday

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am	541, 502, 493, 503, 585	504	586	
6-9:30am	510, 588, 545, 547, 590, 592, 507, 508, 514, 543, 546, 548, 556, 552, 553, 557, 593, 594, 596	505, 506, 509, 511, 512, 544, 549, 550, 551, 551, 558, 559, 589, 595	513, 542, 555, 591	554
9:30-3pm	568, 572, 573, 515	518, 571	481, 582, 584, 516, 517, 519, 560, 563, 566, 567	480, 482, 483, 562, 564, 565, 569, 570
3-6:30pm	488, 525, 528, 574, 578, 485, 521, 524, 526, 531, 577	489, 527, 529, 534, 575, 576	487, 530, 532, 579	486, 522, 530, 533
>6:30pm	536, 490, 497, 498, 501, 535, 537, 580, 581	491, 500	494, 496, 499, 538	492, 495, 538, 540, 582, 585
Pedestrians crossing the tracks less than 15 seconds prior to train coming	488-1 @SB, 13 sec 536-1 @SB, 13 sec 545-1 @ SB, 13 sec 590-3 @ SB, 11 sec 590-2 @ SB, 8 sec 592-1 @ SB, 13 sec 524-2 @ SB, 10 sec 524- 2 @ SB, 12 sec 531- 1 @ NB, 9 sec 594-1 @ SB, 15 sec 596 -1 @ NB, 5 sec 496-1 @ NB, 7 sec	571-3 @ NB, 15 sec 589-1 @ NB, 7 sec		

TAPE 38

Start: 5-31-01 Thursday

End: 6-4-01 Monday

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am	628, 627			
6-9:30am	634, 638, 630, 665, 701, 597,598, 629, 631, 636, 637, 698, 713, 715, 720, 721	632, 633, 635, 639, 664, 666, 714, 716, 719	600, 697, 699, 716, 722	590,600, 602, 640, 668, 696, 700, 717, 723, 724
9:30-3pm	683, 702, 708, 682, 709, 710	741	603,604,606,608,610, 670, 671, 674, 676, 678, 680, 705, 706	605, 607, 609, 611, 672, 673, 675, 677, 679, 681, 704
3-6:30pm	620, 625, 626, 617, 624, 647, 649	616, 618, 619, 621, 622, 643, 648, 650, 651, 652, 687	613, 615, 623, 644, 654, 655, 684	614, 645, 653, 654, 685, 686, 688, 689, 690
>6:30pm	660, 656, 657, 692		659, 662, 663, 691, 711, 712	658, 661
Pedestrians crossing the tracks less than 15 seconds prior to train coming	665- 1 @ SB, 10 sec 683-5 @ SB, 11 sec	632-1 @ SB, 11 sec 639-1 @ SB, 13 sec 643-1 @ NB, 8 sec 648-1 @ NB, 13 sec 718-1 @ SB, 14 sec	606-2 @ NB, 11 sec 654-8 @ NB, 5 sec 654-6 @ NB, 7 sec 697-1 @ NB, 14 sec 697-1 @ NB, 10 sec	645-1 @ SB, 8 sec 653-1 @ SB, 7 sec 608-1 @ SB, 10 sec 686-2 @ SB, 14 sec 717-1 @ SB, 9 sec 724-1 @ SB, 13 sec

TAPE 39

Start: 06-04-01 Monday

End: 06-07-01 Thursday

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am		758	835	891, 834, 837
6-9:30am	761, 795,840, 727, 762, 769, 796, 841	759, 760, 763, 765, 767, 770, 792, 793, 797, 797, 799, 838, 839, 842, 843, 844	764, 794, 800, 802	726, 798, 801
9:30-3pm	742, 818, 738, 730, 743, 804, 805, 811, 819	728, 773,812, 817	729, 733, 735, 739, 772, 775, 778, 814, 815	731, 734, 736, 737, 774, 777, 778, 803, 807, 808, 813, 816
3-6:30pm	809, 822, 748, 755, 782, 783, 786, 821	744, 746, 753, 754, 756, 779, 780, 781, 823	749, 750, 752, 784, 810	749, 751, 782, 785, 787
>6:30pm	824, 826	789, 825	790, 831	788, 827, 829, 830, 832
Pedestrians crossing the tracks less than 15 seconds prior to train coming	738-1 @ SB, 10 sec 761-2 @SB, 5 sec 761-3 @SB, 8 sec 761-5 @SB, 10 sec 727-1 @ SB, 14 sec 755-1 @ SB, 10 sec 755-1 @ SB, 13 sec 762-1 @ SB, 14 sec 782-3 @ NB, 6 sec 805-1 @ SB, 12 sec 819-1 @ SB, 7 sec	754-3 @ SB, 12 sec 760-1 @ SB, 10 sec 760-1 @ SB, 11 sec 780-1 @ SB, 6 sec 823-1 @ NB, 7 sec 843-1 @ SB, 9 sec 843-1 @ SB, 11 sec	737-3 @ NB, 11 sec 815-1 @ NB, 12 sec	735-1 @ SB, 14 sec 751-1 @ SB, 12 sec 778-2 @ SB, 14 sec 803-1 @ SB, 13 sec 803-1 @ SB, 5 sec

TAPE 40

Start: 06-11-01 Monday

End: 06-14-01 Thursday

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am	68, 991, 27, 69	28	70, 22	992, 71
6-9:30am	33, 36, 993,994, 995, 997, 972, 996, 998, 1, 34, 35, 38	971, 973, 974, 999, 1000, 29, 30, 31, 32, 39, 77, 78, 79, 80		40
9:30-3pm	5, 4, 46	7, 39	975, 3, 6, 8, 9	976, 4, 47
3-6:30pm	60, 51, 61	10, 12, 13	11, 14	986, 14, 15
>6:30pm	987, 17, 62, 63	18, 64	21, 22	986, 988, 989, 19, 20, 65, 66, 67
Pedestrians crossing the tracks less than 15 seconds prior to train coming	60-1 @ SB, 11 sec 996-1 @ SB, 9 sec 17-1 @ SB, 7 sec 17-1 @ SB, 9 sec 27-1 @ SB, 10 sec 69-1 @ SB, 12 sec	971-1 @ SB, 14 sec 10-1 @ SB, 14 sec 12-1 @ SB, 13 sec 18-1 @ NB, 8 sec 80-2 @ NB, 11 sec 80-1 @ NB, 10 sec		

TAPE 41

Start: 06-14-01 Thursday

End: 06-18-01 Monday

Time Slots	SB LRT Then NB LRT	NB LRT Then SB LRT	UPRR and NB LRT	UPRR and SB LRT
<6:00 am	162	205	163, 187, 206, 208	207
6-9:30am	82, 86, 118, 119, 130, 190, 83, 114, 120, 131	85, 115, 122, 126, 191	116, 117, 121, 122, 124, 125, 128, 129, 132	87, 123, 127, 129, 133, 189
9:30-3pm	171, 97, 98	168, 169, 195	88, 92, 96,139, 143, 144, 145, 146, 170, 174, 175, 177, 192, 194	90, 91,94, 95, 172, 173, 176, 193, 196
3-6:30pm	101, 152, 99, 100, 105, 106, 148, 151,153, 179	102, 104, 149, 150	197, 200	147, 178, 181, 198, 199
>6:30pm	154, 108, 100, 201	160, 202, 204	110, 111,112, 156, 184, 186	107, 155, 161, 183, 185, 203
Pedestrians crossing the tracks less than 15 seconds prior to train coming	154-1 @ SB, 11 SEC 152-2 @ SB, 14 SEC 100-2 @ NB, 9 SEC 105-2 @ NB, 6 SEC 106-1 @ SB, 11 SEC 106-1 @ NB, 7 SEC 114-1 @ NB, 10 SEC 131-1 @ SB, 9 SEC 153-1 @ NB, 14 SEC 153-2 @ NB, 11 SEC 153-1 @ NB, 10 SEC	169-4 @ SB, 9 SEC 169-1 @ SB, 12 SEC 202-2 @ SB, 12 SEC 150-1 @ SB, 10 SEC 150-1 @ SB, 12 SEC	92-1@ NB, 8 SEC 96-10 @ NB, 9 SEC 117-1 @ NB, 9 SEC 200-2 @ SB, 7 SEC 200-6 @ NB, 10 SEC	107-1 @ SB, 5 SEC 181-1 @ SB, 12 SEC 183-1 @ SB, 7 SEC

ATTACHMENT C: BEFORE INSTALLATION INTERCEPT SURVEY QUESTIONNAIRE

Vernon Avenue Crossing Intercept Survey

Hello, I am _____ with the **Applied Management & Planning Group (AMPG),** a local transportation research firm. We are conducting a survey for the Los Angeles County Metropolitan Transportation Authority (MTA) to test different pedestrian warning signs at the Vernon Avenue Crossing. Your opions are very important. This will take about two minutes.

1. How many times a week do you board the Metro Blue Line at this station?

- ☐ 1 Two or more times a day
- ☐ 2 One time per day
- ☐ 3 One time a week
- ☐ 4 Less than once a week
- ☐ 5 Not at all
- ☐ 6 Refused

2. How many times a week do you cross the tracks here?

- ☐ 1 Two or more times a day
- ☐ 2 One time per day
- ☐ 3 One time a week
- ☐ 4 Less than once a week
- ☐ 5 Refused

3. Do you transfer to or from a bus?

- ☐ 1 Yes
- ☐ 2 No
- ☐ 3 Refused

4. On a 1 to 5 scale, with 1 being not dangerous at all and 5 being very dangerous, could you tell me how dangerous it is to cross the tracks here?

- ☐ 1 1 (Not dangerous at all)
- ☐ 2 2
- ☐ 3 3
- ☐ 4 4
- ☐ 5 5 (Very dangerous)
- ☐ 6 Refused

5. How do you know a train is coming? What do you hear and what do you see? (*check all that apply*)

- ☐ Bell
- ☐ Gate
- ☐ See Train
- ☐ Refused
- ☐ Train Horn
- ☐ Flashing Lights
- ☐ Traffic Signal

6a. Have you ever entered the grade crossing when the bells and flashers are on?

- ☐ 1 Yes (Go to Q6b.)
- ☐ 2 No
- ☐ 3 Refused

6b. What are your reasons for doing so? (*check all that apply*)

- ☐ I thought it was safe
- ☐ I saw the train at the station
- ☐ I was trying to catch the bus
- ☐ I was in a hurry
- ☐ Refused

(***Interviewer: alternate Sign 3 and Sign 4. Ask Questions 7a, 7b, and 7c for Sign 3, and Questions 8a, 8b, and 8c for Sign 4***)

(***Show Sign 3***) **This is a warning sign that can be installed at where you can see when you enter this crossing.**

7a. What does this sign (Sign 3) tell you?

_____

_____

_____

7b. Does this sign (Sign 3) remind you to stop and look both ways before crossing the tracks?

☐ 1 Yes ☐ 2 No ☐ 3 Refused

7c. Does this sign (Sign 3) remind you to stop and look for more than one train before crossing the tracks?

☐ 1 Yes ☐ 2 No ☐ 3 Refused

Vernon Avenue Crossing Intercept Survey

(*Show Sign 4*) This is another warning sign that can be installed at where you can see when you enter this crossing.

8a. What does this sign (Sign 4) tell you?

_____

_____

_____

8b. Does this sign (Sign 4) remind you to stop and look both ways before crossing the tracks?

☐ 1 Yes ☐ 2 No ☐ 3 Refused

8c. Does this sign (Sign 4) remind you to stop and look for more than one train before crossing the tracks?

☐ 1 Yes ☐ 2 No ☐ 3 Refused

(Show Signs 1, 2, 3 and 4)

9. Which sign do you think whould be most effective in reminding you to stop and look for more than one train before crossing the tracks?

☐ 1 Text Sign 1
☐ 2 Text Sign 2
☐ 3 Graphic Sign 3
☐ 4 Graphic Sign 4
☐ 5 Cannot read text signs
☐ 6 Don't know
☐ 7 Refused

10. To what extent do you think one of these signs will improve safety at this crossing? (*read list*)

☐ 1 Great extent
☐ 2 Some extent
☐ 3 Not at all
☐ 4 Don't know
☐ 5 Refused

Demographics

11. What is your age group?

☐ 1 16 or younger
☐ 2 17 to 29 years
☐ 3 30 to 64 years
☐ 4 65 or older
☐ 5 Refused

12. To which of the following racial or ethnic groups do you feel you most belong? (*check one*)

☐ 1 African American
☐ 2 Asian
☐ 3 Latino
☐ 4 White (non Latino)
☐ 5 Other *(specify)*: _____
☐ 6 Refused

For Interviewer Only:

Please note if respondent had one of the following:

☐ 1 Wheelchair
☐ 2 Pushing cart or stroller
☐ 3 Walking with small children
☐ 4 Other

Interviewer Initial:_____

Date: month____day____

Respondent's gender: ☐ 1 M ☐ 2 F

Language in which survey was conducted:

☐ 1 English ☐ 2 Spanish

ATTACHMENT D: AFTER INSTALLATION INTERCEPT SURVEY QUESTIONNAIRE

Vernon Avenue Crossing Intercept Survey 2000

Hello, I am _____ with the **Applied Management & Planning Group (AMPG),** a local transportation research firm. We are conducting a survey for the Los Angeles County Metropolitan Transportation Authority (MTA) to test the pedestrian warning sign at the Vernon Avenue Crossing. Your opinions are very important. This will take about two minutes.

1. Have you seen the yellow flashing train sign at the entrance to this station?

❒ 1 Yes
❒ 2 No *(go to Question 3)*
❒ 3 Not sure *(go to Question 3)*

2. ***(Show sign)***
Is this the sign you mean?

❒ 1 Yes *(go to Question 4)*
❒ 2 No

3. ***(Show sign)***
This is the sign we were talking about. Have you seen it flashing?

❒ 1 Yes
❒ 2 No *(terminate)*

4. What does this sign tell you?

---

5. Does this sign remind you to stop and look both ways before crossing the tracks?

❒ 1 Yes ❒ 2 No ❒ 3 Refused

6. Does this sign remind you to stop and look for more than one train before crossing the tracks?

❒ 1 Yes ❒ 2 No ❒ 3 Refused

7. To what extent do you think this sign improves safety at this crossing? (*read list*)

❒ 1 Great extent
❒ 2 Some extent
❒ 3 Not at all
❒ 4 Don't know
❒ 5 Refused *(don't read)*

8. How many times a week do you board the Metro Blue Line at this station?

❒ 1 Two or more times a day
❒ 2 One time per day
❒ 3 One time a week
❒ 4 Less than once a week
❒ 5 Not at all
❒ 6 Refused

9. How many times a week do you cross the tracks here?

❒ 1 Two or more times a day
❒ 2 One time per day
❒ 3 One time a week
❒ 4 Less than once a week
❒ 5 Refused

10. How do you know a train is coming? What do you hear and what do you see?
(Check all that apply)

❒ 1 Bell
❒ 2 Gate
❒ 3 See Train
❒ 4 Yellow Flasing Sign
❒ 5 Traffic Signal
❒ 6 Flashing Lights
❒ 7 Train Horn
❒ 8 Refused

That's all the questions I have. Thank you for your time.

(Interviewer: fill out back page)

Vernon Avenue Crossing Intercept Survey

Demographics

For Interviewer Only:

Please note if respondent had one of the following:

- ☐ 1 Wheelchair
- ☐ 2 Pushing cart or stroller
- ☐ 3 Walking with small children
- ☐ 4 Other

Interviewer Initial:_____

Date: month_____**day**_____

Respondent's gender: ☐ 1 M ☐ 2 F

Language in which survey was conducted:

☐ 1 English ☐ 2 Spanish

This page intentionally left blank

PART 2: MARYLAND MASS TRANSIT ADMINISTRATION

CONTENTS

SUMMARY

Chapter 1 provides an introduction to the project test site, as well as a statement of the problem and a listing of the project objectives. Chapter 2 describes the process of selecting the new warning sign and its installation and activation. It includes a description of the methodology used for data collection as well as the measures required to obtain a meaningful evaluation for the new warning system. Chapter 3 focuses on the project data and its interpretation. This section includes the analysis and findings of the observations performed before and after installing the new warning system. It also details the results of a motorists' survey, sent to 10,000 residents in the Timonium area, about the effectiveness of the new warning system. Finally, Chapter 4 provides the MTA's conclusions.

CHAPTER 1

INTRODUCTION AND STATEMENT OF PROBLEM

The Baltimore Central Light Rail Line (CLRL) is a 33-mile-long system. It is operated and maintained by the Maryland Mass Transit Administration (MTA). Completed in 1992, the CLRL extends between the Cromwell Station in Glen Burnie to the south, and the Hunt Valley Station in Baltimore County to the north (see Figure 1). One of the most challenging aspects that the system has experienced since its opening is the "second train coming" phenomenon that occurs on double track crossings such as the Timonium Road crossing in Baltimore County. Fortunately, no serious accidents have occurred at this crossing; however, there have been numerous conflicts and a continuous potential for collisions to occur between light rail vehicles and motor vehicles. Approximately 100 gate arms were crashed and subsequently repaired at the Timonium crossing between 1992 and 1996. Although no investigation linked these accidents to the "second train coming" phenomenon, the possibility exists that it may have been a contributing factor.

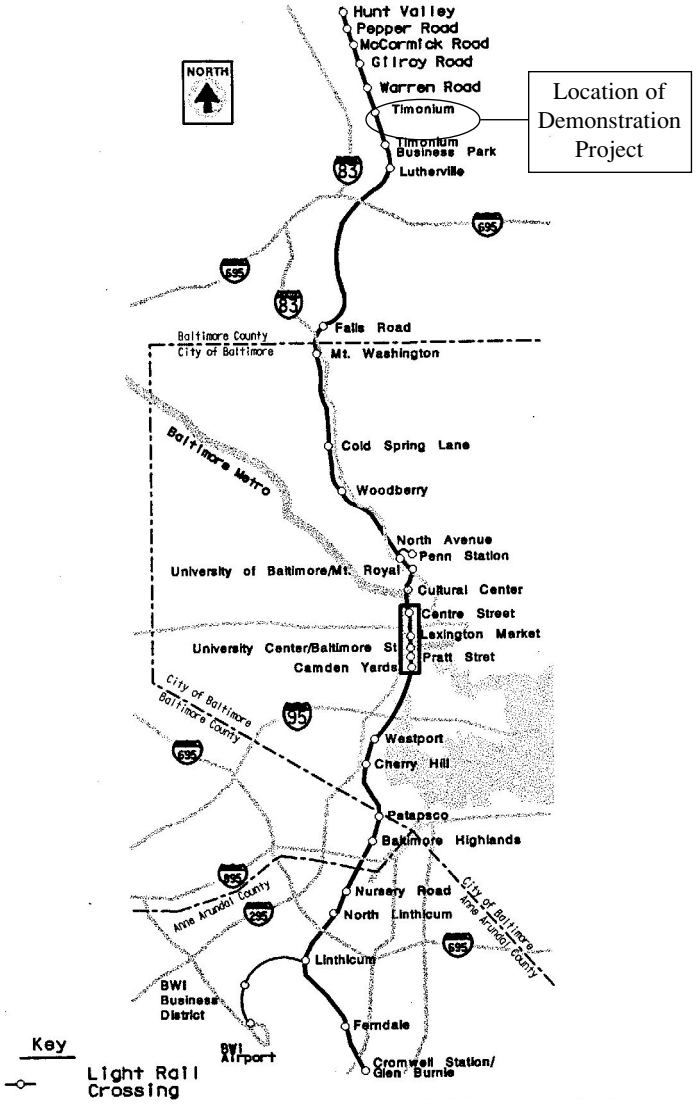


Figure 1. Location Map of Baltimore CLRL System.

The CLRL Timonium grade crossing is located in northern Baltimore County. It is the sixth crossing south of the CLRL terminus at Hunt Valley. The Timonium grade crossing, which extends in north-south directions, is located on Timonium Road, approximately 1,250 ft east of interstate I-83 and north of the Baltimore Beltway I-695. Timonium Road runs in an east-west direction. It is a four-lane undivided arterial with sidewalks on both sides. Traffic signals exist on both sides of the tracks, within 500 ft. The Timonium State Fairgrounds, which is a major generator of vehicular and pedestrian movements, is located north of Timonium Road. Sidewalks on the north and south sides of Timonium Road cross both CLRL tracks. There is no CLRL station in the immediate vicinity of the crossing. The grade crossing signaling equipment consists of warning devices such as flashing lights, gates, and a bell. These devices are activated when a train is approaching the crossing. As the train exits the crossing, the gates and warning devices are deactivated to allow vehicles and pedestrians a continued passage on Timonium Road. Photographs A-1 through A-4 in Appendix A show the CLRL crossing and approaches on Timonium Road.

With the scheduled train meeting points currently occurring just north of the grade crossing, one of two trains traveling from opposite directions frequently activates the grade crossing equipment within seconds after the first train has entered the crossing gate activation circuits. If the first train

has vacated the grade crossing, the presence of the second train causes the gates to come back down before reaching their full vertical position. Otherwise, the gates remain down as the second train passes through the grade crossing. This situation is known as a second train coming (STC) incident. The focus of this project is how to effectively warn motorists that a second train is approaching the Timonium grade crossing.

OBJECTIVES

The objective of this demonstration project is to identify and demonstrate an active signing warning system that will increase motorists' awareness of and compliance with the conditions of an STC phenomenon. Furthermore, an objective of the project is to measure the effectiveness of the active sign warning system. Measurement was performed through motorist behavior observation and analysis. MTA held the viewpoint that with a successful warning system, safety to motorists and pedestrians will be enhanced. This hypothesis could be confirmed through measurements of reduced risky behaviors during STC incidents. MTA performed the research for this project, with funding provided by the Federal Transit Administration (FTA) through the Transit Cooperative Research Program (TCRP).

DEFINITION OF THE PROBLEM

The Timonium crossing is a heavily traveled highway-rail intersection. Trains at the crossing operate at a speed of 50 mph. Because of the system design and train scheduling limitations, the meeting point of two crossing trains most often occurs north of the Timonium crossing rather than at the crossing or within the visual range of motorists. The gate activation circuits are located at 1,760 ft (equivalent to 24 seconds warning time at the crossing) on each approach, north and south, of the CLRL crossing (see Figure 2). A second detection clearance envelope is also located at 528 ft past the crossing area in each direction. When two trains coming from opposite directions are detected within the gate activation circuits, the gates and other warning devices stay activated until both trains have completely departed the gate activation circuit areas. However, when the meeting point of two trains is outside the gate activation circuits, the gates and warning devices that are activated and deactivated by the first train are frequently subsequently activated again by the second train within 10 seconds after the first deactivation has occurred. Typically, this STC phenomenon occurs about 10 times per day.

The above situation is very confusing to motorists and pedestrians. Motorists and pedestrians very often start to proceed through the crossing when the gates begin to ascend

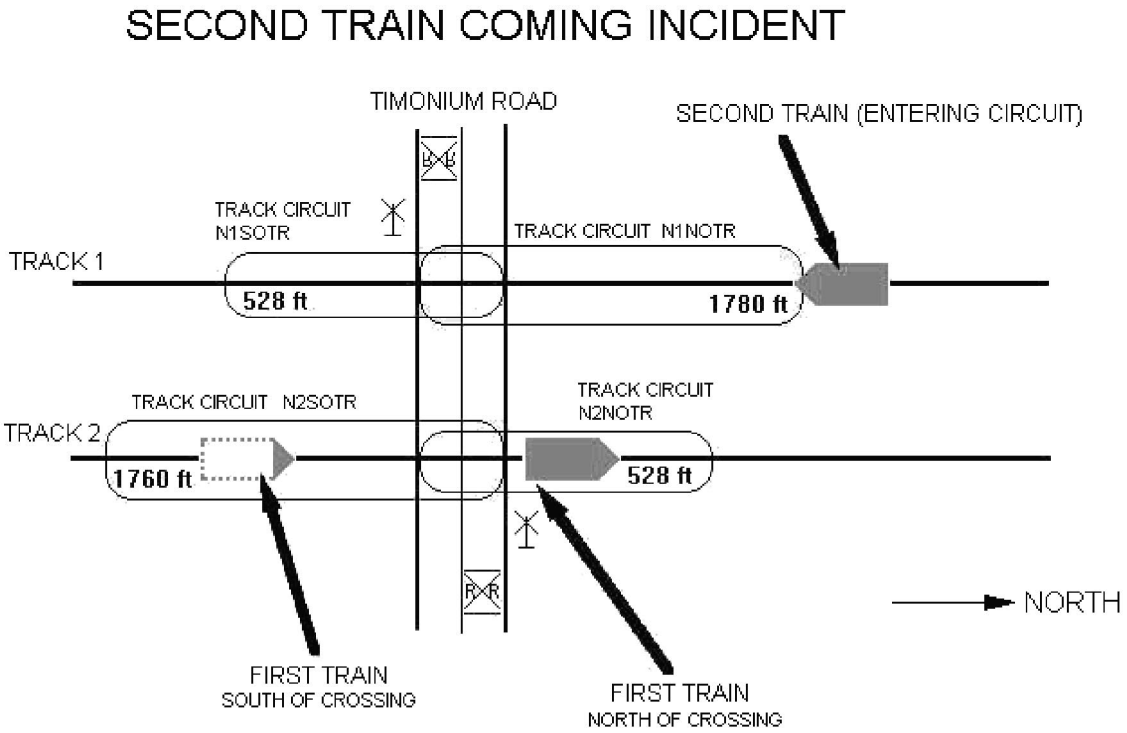


Figure 2. Schematic of Gate Activation Circuits.

in the vertical position as a northbound train exits the crossing, only to be abruptly stopped as the gates descend again because a second southbound train has entered the gate activation circuit. In this situation, the cars are stopped very close to the tracks and could be in the fouling envelope of an oncoming train. The fouling envelope is defined as an area close to the tracks where a crossing train could collide with vehicles stopped within this area.

This situation constitutes one example of the STC phenomenon. In another scenario, the second train enters the crossing approach detection circuits after the first train has entered its approach and has already activated the crossing warning equipment. In this scenario, the first train will pass through the crossing before the second train is within visual range of motorists who are stopped behind the gates. The gates remain down due to the unseen approach of the second train. Following passage of the second train through the intersection, the crossing warning equipment is deactivated. This situation poses a risk to motorists who might assume that the crossing gate mechanism is broken because the gates remained down after the train cleared the crossing. At this point, motorists may not be aware that a second unseen train is approaching the crossing from the opposite direction.

CHAPTER 2

MTA PROPOSED SOLUTION METHODOLOGY

To meet the objectives of this project, it was determined that the following tasks must be accomplished:

- General sign parameters
- Selecting sign size, messages and displays
- Sign selection survey
- Mounting the sign
- Pedestrian signals treatment
- Analyzing quantitative risky behavior data of motorists and pedestrians to evaluate the effectiveness of the new STC warning sign before and after the STC warning system is installed, as follows:

    1. Data collected during the Maryland State Fair
    2. Pre-installation and post-installation data collection (August/September 1998)
    3. Post-installation data collection (October 1998)
    4. Motorist questionnaire survey

GENERAL SIGN PARAMETERS

The concept for improving the safety of the Timonium grade crossing was targeted to provide additional information for vehicular traffic through the use of microprocessor or advanced technology controlled signs with graphic capabilities. Before proceeding with the selection of the graphic sign, several issues were considered. These issues included the following:

- The sign should be positioned so that all motor vehicle traffic approaching the crossing will have an unobstructed view of the sign at any given time.
- The sign should be large enough to permit reading of the message by vehicles stopped behind the gates. Also, the sign display should be easy to comprehend by the majority of drivers. It was decided that the message would have minimal text content. The majority of the message would consist of a language-independent animated graphic.
- The sign should employ illumination controls that permit unobstructed visibility in various types of weather, daylight, nighttime, sunrise, and sunset conditions. The sign display should employ state-of-the-art technology to provide superior illumination and contrast.
- The sign graphics should be dynamic and convey the intended message as simply as possible. Supplemental flashing beacons may be added to the signs to attract motorists' attention.
- The color of the text/graphics must be amber to comply with the *Manual on Uniform Traffic Control Devices* (MUTCD) guidelines for warning signs.

Using the above criteria, several sign manufacturers were contacted. These manufacturers included the following:

1. Sunrise Systems, Inc. (Pembroke, Massachusetts)
2. Daktronics, Inc. (Brookings, South Dakota)
3. Groupe Infocite, Inc. (Montreal, Canada)
4. Action Media Technologies (Chatsworth, California)

SELECTING SIGN SIZE, MESSAGES AND DISPLAYS

In collaboration with the MTA, the FTA outlined the general criteria for the new sign during an initial meeting in Baltimore during the summer of 1996. The FTA's suggested criteria required that the sign have an active display and be activated based upon the presence of a second train. The active display is intended to show a graphic message that could be understood by a person who is not fluent in English. A suggestion was provided for an animation of trains with the speed of the animation similar in scale to that of the actual moving trains. The display could be supplemented with a text message.

After further research of the available sign display technologies, it was determined by the MTA's Systems Engineering Department that the light emitting diode technology has the best potential for this application. The light emitting diode (LED) is a semi-conductor technology and operates

using the same principles as transistors and computer chips. This technology was chosen over the flip-dot matrix type due to the quick response of LEDs for animation sequences. The LED is also a popular technology used in transit signing. The color for the message and graphic display was chosen to be amber, in accordance with the MUTCD's guidelines for warning messages.

In March 1997, the MTA formed a committee to develop the content of the sign. The committee consisted of representatives from the MTA's Customer Relations, Engineering, and Maintenance departments. The committee reviewed an FTA report on light rail signage, along with the proposed second train warning sign messages developed by the Los Angeles Metro. The Los Angeles Metro's signage proposal depicted a motorist view of a highway-rail intersection with an illustration of trains approaching the crossing. The committee determined to use a similar sign for the content of the MTA's STC display.

After a further survey and screening of candidate sign manufacturers, the selected STC sign was manufactured by Action Media Technologies (AMT) of Chatsworth, California, and delivered in late May 1998. The selection was based primarily on cost. The cost of the two manufactured signs was $30,000. The LED sign was built with a dot-matrix of 64 × 128, with an LED spacing of 0.3 in., based on a sign size of 2 ft high and 3.5 ft wide. This size was selected based on the optimal viewing distance of 50 ft, which is the approximate distance between the sign and the first vehicle behind the gate. Cost and the available budget for this project were at least two factors for not selecting a larger sign for this demonstration project.

After several meetings held by the MTA's Sign Selection Committee, during 1997 and early 1998 the committee devised the prototype message shown in Figure B-1 in Appendix B. The illustration in Figure B-1 shows only one frame of the entire message. When viewed as an animation, the two trains moved into the center of the sign from the left and right borders of the sign and continued to move through the grade crossing. The sequence of the train movement repeats itself along with a text message "WARNING" flashed on and off.

When the message in Figure B-1 was programmed into the STC sign and reviewed by the committee, several alterations were identified. The alterations included making the trains appear larger, having the trains more closely resemble light rail vehicles, and making the trains move faster. Alterations to the text message included having the text displayed separately from the graphics so that the "WARNING" (see Figure B-2 in Appendix B) appeared prior to the graphic animation, and adding additional text saying "2nd TRAIN COMING" (see Figure B-3 in Appendix B) to appear after the graphic animation.

Based on the identified alterations, a total of three messages were developed and programmed into the STC sign. The three warning messages consisted of the following.

Sign Display A

This display showed a flashing text message "WARNING" for 2.5 seconds, (Figure B-2 in Appendix B), followed by an animation sequence of two trains crossing the intersection from two opposite directions for 4 seconds (Figure B-4 in Appendix B), followed by a steady text message "2nd TRAIN COMING" for 2.5 seconds (Figure B-3 in Appendix B). The total time to display all three sequences was 9 seconds.

"WARNING" — <Train Animation> — "2nd TRAIN COMING"

Sign Display B

This display showed a flashing text message "WARNING" for 2.5 seconds (Figure B-2 in Appendix B), followed by a steady text message "2nd TRAIN COMING" for 2.5 seconds (Figure B-3 in Appendix B), followed by an animation sequence of two trains crossing the intersection from two opposite directions for 4 seconds (Figure B-4 in Appendix B). The total time to display all three sequences was 9 seconds.

"WARNING" — "2nd TRAIN COMING" — <Train Animation>

Sign Display C

This display showed the animation sequence of two trains crossing the intersection from two opposite directions, along with a constant flashing text message "WARNING" (Figure B-1 in Appendix B).

<Train Animation> & "WARNING"

The MTA conducted a survey to decide which of the three messages is best for the new warning sign.

SIGN MESSAGE SELECTION SURVEY

To formalize the final sign message selection, a survey was conducted on August 21 and August 24, 1998, at the MTA's main office in downtown Baltimore. The survey included 23 people consisting of Baltimore MTA employees, including the MTA administrator and several senior managers. The three messages for the STC warning sign discussed in the previous section were displayed (see the questionnaire in Appendix C).

Each of the three messages was displayed on the actual sign in a conference room. Each participant was requested to select one of three descriptions of the intended message of the three displays. The three choices were as follows:

A. Sign message and graphical illustration indicate that I should not travel through the intersection because a train from any direction is about to cross the intersection.
B. Sign message and graphical illustration indicate that I should not travel through the intersection because a train

has just passed the intersection and a second train is about to arrive at the intersection from the other direction.

C. Sign message and graphical illustration indicate that it is okay to travel through the intersection because the trains have already crossed the intersection.

The survey results were as follows:

- Twenty-three questionnaires were filled out.
- Three people chose Sign Display C as the most appropriate message.
- Five people agreed that Sign Display A was more appropriate than either of the other two messages.
- Fifteen people chose the Sign Display B as the most appropriate message.
- Some of the comments received for Sign Display B were: "Preferred signage - I like the message before the graphics," "The sequence is more understandable," "Just right," " Best of three," and "First choice."
- Some of the comments received for Sign Display C were: "Too slow," "Too small," "Did not like this illustration," "Not clear," and "Need to make too many assumptions." On the positive side, this comment was received: "All message in one screen."
- Other general comments included the following:

    1. Trains need to move faster.
    2. Is "2nd Train Coming" universally understood?
    3. Remove graphics and leave the warning sign.
    4. Put an article in the newspaper and television to inform public.
    5. Consider also an audible signage.
    6. Message should convey the need to stop until 2nd train passes.

Overall, the majority (82 percent) of participants agreed that Sign Display B was the best message to increase awareness of the STC. The chosen message for the STC sign consisted of a display, which included a flashing appearance of Figure B-2 in Appendix B, followed by a steady appearance of Figure B-3, followed by the animation sequence illustrated by Figure B-4; that is, "WARNING" — "2nd TRAIN COMING" — <Train Animation>. This display was supplemented with flashing beacons to attract motorists' attention to the new STC sign.

MOUNTING THE SIGN

The existing structure at the Timonium crossing consists of the Safetran ARC-100 type cantilever on each of the approaches on Timonium Road. Each cantilever consists of a 17-ft-high aluminum upright post with an 8-in. diameter. The cantilever arm length is 22 ft. A single railroad crossing warning sign is banded to the aluminum upright post, and railroad flashing lights are mounted on both the upright post and the cantilever arm. (See Photograph A-1 in Appendix A).

In August 1998, Safetran Systems Corporation confirmed that the ARC-100 type Safetran cantilever sign structure was designed based on a 250-lb, add-on load at the end of the cantilever arm. Also, the MTA confirmed that the total load of the message sign, including the mounting assemblies, is a maximum of 160 lb. (See Photograph A-5 in Appendix A.)

The MTA engineering consultant conducted a further structural analysis of the cantilever structure. It was determined that the centerline of the STC sign should be mounted at no further than 11 ft from the center of the 8-in. aluminum upright post. This would minimize the increase of the bending stress loads on the cantilever arm due to the sign weight as well as the torsion stresses on the post and foundation that may be caused by the wind load. The STC signs were installed on Sunday, August 23, 1998, and activated at 8:30 AM on Friday September 4, 1998. One sign was installed on each of the cantilever arms, as shown in Photograph A-5 in Appendix A.

A detailed description of the electronic circuit design of the STC sign is included in Appendix D. It includes a description of the STC detector circuit, the STC line circuit, the STC display driver enable circuit, the STC driver circuit, the STC CCTV trigger circuit, the STC power distribution circuit, the STC sign junction box, and the pedestrian signals control circuit.

PEDESTRIAN SIGNALS TREATMENT

An ancillary goal of the STC project was to provide additional safety equipment to govern pedestrian movements across the railroad tracks. At each corner of the Timonium crossing, pedestrian WALK / DON'T WALK signals were installed (see Figure 3). The signals are capable of displaying either a walking man icon or a hand icon to guide pedestrians who are crossing the tracks at the grade crossing. These signals are controlled by the presence of any train moving through the grade crossing.

The pedestrian signals display a steady walking man icon (WALK) at all times except when a train is detected within the circuit envelope, i.e., within 24 seconds on each approach of the tracks. Within 4 seconds after detecting a train, the pedestrian signals change from a steady walking man icon to a flashing hand icon (FLASHING DON'T WALK). The flashing hand icon is displayed for a period of 13 seconds, based on a maximum crossing distance of 52 ft. Subsequently, the pedestrian signals change to a steady display of the hand icon (DON'T WALK) until the train has cleared the intersection and the gates are in the upward position.

The pedestrian (PED) signals consisted of the McCAIN Traffic Supply Series 1000 single-head incandescent pedestrian signals. The signals use 68W traffic signal bulbs powered by 120 VAC via the PED controller inside of

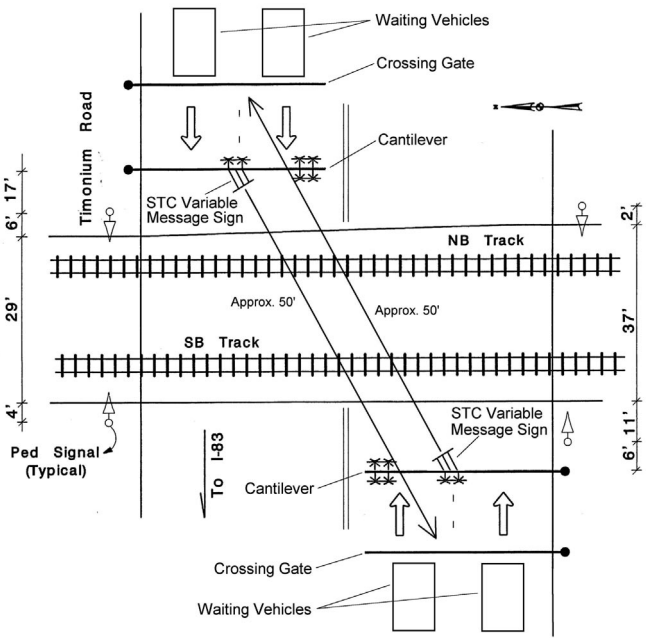


Figure 3. Schematic of CLRL Crossing at Timonium Road.

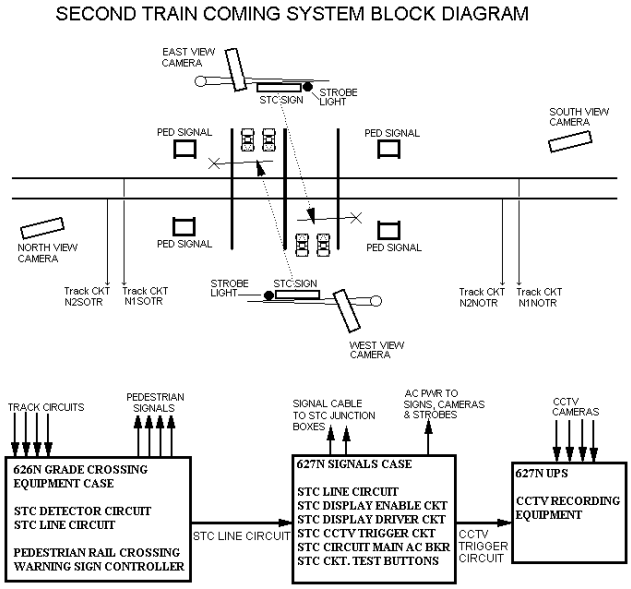


Figure 4. STC System Block Diagram.

Wayside Instrument Case (WIC) 626N. The signals were side mounted on 10-ft breakaway poles. The bases were set on 6-ft-deep concrete foundations. An electrical ground rod was installed and connected to each signal base. The materials used for the signals, masts, bases, and foundations meet the requirements as set by the Maryland State Highway Administration for such equipment. (See Photograph A-6 in Appendix A).

In mid-October of 1998, a modification was made to the control circuit for the pedestrian signals. The modification consisted of preventing the walking man icon from being displayed until the gates are vertical and the train flashing lights have ceased to flash. Previously, the walking man icon was displayed when the train(s) were clear of the crossing, although the flashing lights were still flashing. This change was made to better coordinate the operation of the pedestrian signals with the operation of the crossing gates and vehicular movements.

CLOSED CIRCUIT TELEVISION CAMERAS FOR DATA COLLECTION

A comparison of motorists' behavior "before" and "after" the installation of the new STC warning system was essential to evaluate the effectiveness of the new STC warning sign. Closed circuit television (CCTV) cameras recorded the data, and a comparison was performed. Four CCTV cameras were employed on this project. The cameras, mounted on the cantilever structures and catenary poles, recorded motorists' and pedestrians' risky behavior from four different angles: north, south, east and west of the crossing. These cameras were only activated to record data during STC occurrences.

Figure 4 illustrates the STC system block diagram that controlled the activation of the CCTV cameras. Wayside Instrument Case (WIC) 626N has a vital relay circuit (STC) that senses the STC event based on the grade crossing track circuits. A vital circuit at WIC626N controls a repeater relay (STCP) at WIC627N. The electrical connection between WIC626N and WIC627N utilizes existing wires within the MTA's express cable. At WIC627N, two vital relays (STCP, STCDRV) activate the STC graphic signs and strobe lights that are mounted on both grade crossing cantilevers. The same circuitry also triggers the alarm signal to the CCTV recording equipment located inside of the 627N UPS shelter.

Activation of the STC signs and strobe lights involves switching 24 volts DC to a pair of control relays located inside junction boxes near each STC sign. One of the control relays switches 120 volts AC to the strobe light. The other control relay provides a dry contact closure to a set of message activation contacts for the STC sign.

The CCTV recording equipment at UPS627N consists of a VCR and analog multiplexer that interfaces to four external CCTV cameras. The design of the CCTV equipment is such that the cameras always operate and the recording equipment is set for recording only during an alarm condition. When the CCTV equipment receives an alarm signal due to an STC event, the CCTV VCR will record the four cameras until the STC event no longer exists.

Electrical power distribution for all STC-related equipment is fed from location 627N via a 30A utility feed. At the UPS627N location, a power line conditioner and lightning

arrestor have been installed to provide protection and filtered AC power to the STC signs, strobe lights, and CCTV cameras. A 30A breaker is present in the STC AC distribution circuit at location 627N.

Conduits and junction boxes have been installed to accommodate interconnection between all STC equipment. An existing spare conduit is used between WIC627N and the UPS627N to provide interconnection for CCTV and the STC wiring.

MEASURES OF EFFECTIVENESS

Data was collected before and after installing the STC warning sign during the months of August, September and October 1998. Also, special emphasis focused on collecting data during the last two weeks of August when pedestrian traffic in the vicinity of the grade crossing was highly congested due to the Maryland State Fair.

The recorded data consisted of risky behavior observations. "Risky behavior" is defined by the MTA as the behavior of light rail operators, motor vehicle drivers, bicycle operators and pedestrians that increases the risk of an accident. The recorded risky behavior data included the following:

- Pedestrians crossed the tracks while gates were down
- Pedestrians crossed Timonium Road in front of downed gates
- Motorists drove around a downed gate
- Vehicles remained stopped on tracks
- Drivers crossed gate line, but stopped after realizing that a second train was coming and drove backward behind the line to avoid the gate crashing on their vehicles
- Vehicles stopped in front of the gate while a train was crossing
- Gates descended on vehicles
- Vehicles crashed gates
- Drivers started to move forward after the first light rail vehicle crossed Timonium Road and the gates were down, but stopped after realizing that a second train was coming
- Vehicles crossed the tracks *after* the first light rail vehicle cleared Timonium Road while the gates were ascending but had not reached the full upward vertical position, and *before* the gates descended again for the second light rail vehicle

Risky behavior data was recorded on VHS cassettes. Subsequently, the data was reduced, tabulated and analyzed as a measure of effectiveness of the new STC system. Reducing the data was performed by a single person, a traffic engineer, who was trained to understand the project and each of the above risky behavior observations. Training and consistency were two important factors in the data collection and reduction in order to derive meaningful and accurate results.

CHAPTER 3

ANALYSIS OF PROPOSED SOLUTION

Video records were collected during the Maryland State Fair in August 1997 for a 24-hour period. Records were also collected during a 60-day period from July to August 1998, before the activation of the new warning sign. A sample of a 30-day period of data was analyzed and tabulated to show the frequency of risky behavior during STC incidents.

More video records were collected during a 60-day period from September to October 1998, after the activation of the new STC warning sign. The records were also analyzed and tabulated. The comparison was used to evaluate the effectiveness of the STC warning sign.

Finally, a survey was conducted by the Maryland Mass Transit Administration (MTA) during the months of November and December 1998 in the Timonium area to get input from motorists about their opinion on the effectiveness of the STC warning sign. The questionnaire also requested motorists' opinions about the sign position and any other relevant comments.

DATA COLLECTION DURING THE 1997 MARYLAND STATE FAIR

The first analysis was performed for a 24-hour period on August 31, 1997, during the Maryland State Fair, before the STC warning system was installed. The findings were based on reviewing digital images that were provided by the MTA. The analysis focused specifically on "risky behavior" observations.

During the 24-hour period, 106 MTA light rail vehicles were observed crossing Timonium Road. During those crossings, an STC incident occurred 13 times. Table 1 summarizes the findings for the "risky behavior" observations under scenarios of a single light rail vehicle crossing the tracks. Table 2 summarizes the findings under the STC scenarios.

The findings clearly demonstrate that vehicles, most of the time, proceed forward when the crossing gates are ascending but the flashing lights are not extinguished. On six occasions during the 24-hour period, pedestrians were observed crossing the tracks while the gates were down. However, on 37 other occasions, pedestrians waited for the gates to start moving upward before they crossed the tracks.

Under this analysis, the STC incident was observed when the gates remained in the downward position or when they descended again before they were restored to the full upward vertical position following a first train's departure.

On four occasions with a second train coming, vehicles were observed crossing the tracks immediately after the first light rail vehicle crossed Timonium Road and when the gates were ascending, but had not reached the full upward vertical position. Subsequently, the gates descended again for the

TABLE 1 "Risky Behavior" Under Single Light Rail Vehicle Scenarios (1997 MD State Fair)

	Number of Times Observed	Percentage (%)
Pedestrians crossed the tracks while gates were down	3	3%
Motorists crossed tracks while gates were descending	4	4%
Motorists drove around a downed gate	0	0%
Vehicles proceeded when the crossing gates were ascending but the flashing lights were not extinguished	83	90%
Gates descended on vehicles	1	1%
Vehicles crashed gates	0	0%
Total Observations	**93**	**100%**

TABLE 2 "Risky Behavior" Under STC Scenarios (1997 MD State Fair)

	Number of Times Observed	Percentage (%)
Pedestrians crossed the tracks while gates were down	3	8%
Motorists crossed tracks while gates were descending	8	21%
Motorists drove around a downed gate	0	0%
Vehicles remained stopped on tracks	0	0%
Vehicles proceeded when the crossing gates were ascending but the flashing lights were not extinguished	21	55%
Gates descended on vehicles	0	0%
Vehicles crashed gates	0	0%
Drivers started to move forward after the first light rail vehicle crossed Timonium Road, while the gates were down, but stopped after realizing that a second train was coming	2	5%
Vehicles crossed the tracks **after** the first light rail vehicle cleared Timonium Road and the gates were ascending but had not reached the full upward vertical position and **before** the gates descended again for the second coming light rail vehicle	4	11%
Total Observations	**38**	**100%**

second coming light rail vehicle. On these four occasions, an average of ten vehicles crossed the tracks.

On two occasions, vehicles were observed stopped on the tracks as a result of an overflow of traffic from the downstream signal. No trains were crossing Timonium Road during these incidents.

PRE-INSTALLATION AND POST-INSTALLATION DATA COLLECTION (AUGUST/SEPTEMBER 1998)

"Risky behavior" observation analyses were also performed for a 30-day period before and a 30-day period after the STC sign was installed. The findings were based on data extracted from the videotapes that were provided by the MTA.

The 30-day observation period before the STC sign was installed occurred during the period of August 2, 1998, to September 1, 1998. The 30-day observation period after the STC sign was installed occurred during the period of September 3, 1998, to October 2, 1998. A comparison of risky behaviors that were observed and recorded during the study periods is shown in Table 3.

During the 30-day period before the STC sign was installed, an STC incident occurred 320 times, as compared to 363 incidents during the 30-day period after the STC sign was installed.

In the majority of observations, the recorded videotapes did not show the crossing gates while ascending or descending. However, 29 incidents during the "Before" period and 22 incidents in the "After" period were recorded.

On two occasions during the "Before" period, pedestrians were observed crossing the tracks while the gates were down. Likewise, eight similar incidents occurred during the "After" period. At other times, pedestrians waited for the gates to start moving upward before they crossed the tracks; an accurate number of these times could not be determined due to the fact that some observations were not recorded on the videotapes.

TABLE 3 "Risky Behavior" Comparison of "Before Sign" and "After Sign" Measured Data for a Period of 30 Days

	Before Sign was Installed (August 1998)		After Sign was Installed (September 1998)	
	Number of Times Observed	Percentage (%)	Number of Times Observed	Percentage (%)
Pedestrians crossed the tracks while gates were down	2	2%	8	11%
Pedestrians crossed Timonium Road in front of downed gates	2	2%	1	1%
Motorists drove around a downed gate	0	0%	0	0%
Vehicles remained stopped on tracks	0	0%	0	0%
Drivers crossed gate line but stopped after realizing that a second train was coming and drove backward behind the line to avoid the gate crashing on their vehicles	4	5%	6	8%
Vehicle stopped in front of the gate while train was crossing	1	1%	0	0%
Gates descended on vehicles	0	0%	0	0%
Vehicles crashed gates	0	0%	0	0%
Drivers started to move forward after the first light rail vehicle crossed Timonium Road and the gates were down but stopped after realizing that a second train was coming	21	26%	10	14%
Vehicles crossed the tracks **after** the first light rail vehicle cleared Timonium Road while the gates were ascending but had not reached the full upward vertical position and **before** the gates descended again for the second coming light rail vehicle	53	64%	49	66%
Total Observations	**83**	**100%**	**74**	**100%**

Vehicles were observed crossing the tracks immediately after the first light rail vehicle crossed Timonium Road while the gates were ascending, but had not reached the full upward vertical position, and descended again for the second coming light rail vehicle. This behavior was observed on 53 occasions during the "Before" period compared to 49 occasions during the "After" period.

The findings demonstrate a reduction in the number of hesitant drivers from 21 in the "Before" period to 10 in the "After" period. The total number of "Risky Behavior" observations decreased from 83 during the "Before" period to 74 during the "After" period. The findings also show that the majority of drivers still attempt to travel through the grade crossing as soon as the gates begin to ascend.

POST-INSTALLATION DATA COLLECTION (OCTOBER 1998)

To further explore the effect of the new signs, more "Risky Behavior" observation analysis was performed for a second 30-day period after the STC sign was installed. The analysis compared the "Risky Behavior" data observed during the 30-day period before the sign was installed to those

TABLE 4 "Risky Behavior" Comparisons of "Before Sign" and "After Sign" Measured Data for (1) 30-Day Period Before Installation and (2) 30-Day Periods After Installation

	8/98	9/98	10/98		
	Before (1)	1st period "After" (2)	2nd period "After" (3)	Improvement Comparing (1) and (2)	Improvement Comparing (1) and (3)
	Number of Times Observed			Percentage	Percentage
Total number of STC incidents	320	363	348	n/a	n/a
Pedestrians crossed Timonium Road in front of downed gates	0.625 (2)	0.275 (1)	0.000 (0)	-56%	-100%
Drivers crossed gate line, but stopped after realizing that a second train was coming, and drove backward behind the line to avoid the gate crashing on their vehicles	1.250 (4)	1.653 (6)	2.299 (8)	+32%	+84%
Vehicle stopped in front of the gate while train was crossing	0.313 (1)	0.000 (0)	0.000 (0)	-100%	-100%
Drivers started to move forward after the first light rail vehicle crossed Timonium Road, and the gates were down, but stopped after realizing that a second train was coming	6.563 (21)	2.755 (10)	0.862 (3)	-58%	-87%
Vehicles crossed the tracks **after** the first light rail vehicle cleared Timonium Road while the gates were ascending but had not reached the full upward vertical position and **before** the gates descended again for the second coming light rail vehicle	16.563 (53)	13.499 (49)	11.207 (39)	-19%	-32%
Total Observations **	**25.938 (83)**	**20.386 (74)**	**16.667 (58)**	**-21%**	**-36%**

Note: All observations are normalized per 100 STC incidents during each period. The improvement shown is for the normalized observations. The actual number of observations is shown in parentheses.

Example: "6.563 (21)" denotes 6.563 incidences of that particular case per 100 STC occurrences. The actual number of incidences is 21.

** Note: This total includes patterns of behavior not listed above; therefore, this total is greater than the sum of the categories.

observed during the first 30-day period after the sign was installed, and to those observed during a second 30-day period after the sign was installed.

As previously stated, the 30-day observation period before the STC sign was installed occurred during the period of August 2, 1998, to September 1, 1998. The first 30-day "After" period occurred during the period of September 3, 1998, to October 2, 1998, and the second 30-day "After" period occurred during the period of October 2, 1998, to October 30, 1998. The number of occurrences of "risky behavior" that were observed and recorded during the three study periods is shown in Table 4.

During the 30-day period before the STC sign was installed, an STC incident occurred 320 times, compared to 363 times during the first "After" period and 348 times during the second 30-day "After" period.

As shown in Table 4, the total number of risky behavior observations decreased from 83 (a rate of 25.938 observations per 100 STC incidents) during the "Before" period to 74 (20.386 observations per 100 STC incidents) during the first "After" period and 58 (16.667 observations per 100 STC incidents) during the second "After" period. This translates to a 21% and 36% reduction in the rate of incidence, respectively. Also, the findings demonstrate another major reduction in the number of hesitant drivers from 21 during the "Before" period (6.563 per 100 STC incidents) to 10 (2.755 per 100 STC incidents) and only 3 (0.862 per 100 STC incidents) during the first and second "After" periods, respectively.

Another improvement was demonstrated by the decreased frequency of incidents of pedestrians crossing Timonium Road in front of downed gates, which decreased from 2 during the "Before" period to 1 and 0 during the first and second "After" periods, respectively.

MOTORIST SURVEY

In order to increase the public awareness about the STC project at the Timonium crossing, the MTA issued a press release to the media on Thursday, September 3, 1998, announcing the start of the test project. An Internet website for the STC project was developed and linked to the MTA main website. Also, the *Towson Times,* a local newspaper for Towson, Timonium, Lutherville, Cockeysville and Hunt Valley, published an article about the STC project on September 9,1998. The project was also televised and demonstrated on the Baltimore local TV channels 11 and 13. In addition, radio station WBAL AM broadcasted interviews with the MTA throughout the morning of September 4, 1998.

Through the Office of Customer Services and the Office of Engineering, the MTA also conducted a survey for the STC warning sign demonstration during the months of November and December 1998. (See Appendix E.) The survey was sent to 10,000 residents in the Timonium area and included an explanation of the new STC warning system, its purpose, and how it works. The survey requested the motorists' opinion on how effectively the STC sign warned them

TABLE 5 Summary of the Motorist Survey

	Number of responses to the question	Percentage of people who saw the sign	Percentage of people who answered "YES"	Percentage of people who answered "NO"	Percentage of people who answered "DID NOT SEE IT IN OPERATION"	Percentage of people who did not answer the question
Question # 1	1132	35 %	31 % (89 % **)	4 % (11 % **)	65 %	0 %
Question # 2	1002	N/A	81 %	8 %	N/A	11 %
Question # 3	685	N/A	50 %	11 %	N/A	39 %

** NOTE: The percentage of people who saw the sign in operation who answered "Yes" or "No" is shown in parentheses.

that a second train is coming from the opposite direction and if they felt that the new warning system would increase the motorists' safety awareness. The questionnaire also requested motorists' opinions about the sign position and comments pertaining to their perception of the effectiveness of the sign.

The survey included three specific questions:

1. If you have seen the STC system in operation, did it effectively warn you that a second train was coming from the opposite direction?
2. Do you feel the new warning system will increase the safety awareness of motorists?
3. Is the STC sign positioned in good view of motorists stopped at the crossing?

The results of the motorist survey are based on reviewing 1,132 responses that were returned to the MTA; this represents a sampling rate of 11.50 percent. Table 5 summarizes these responses.

CHAPTER 4

CONCLUSIONS

Overall, the findings demonstrate that during the second 30-day period after the new sign was installed, less risky behavior was observed than during the first "After" period. This may be explained in part by the fact that drivers became more cognizant of the sign, and thus started to respond better during the second "After" period. However, it was still observed that the majority of drivers still attempt to travel through the grade crossing as soon as the gates begin to ascend, with or without the indication of a second train coming.

The findings of the survey demonstrate that the majority of people (91 percent of people who answered the second question) feel that the warning system will increase the safety awareness of motorists. Also, the findings indicate that the majority of drivers (82 percent of people who answered the third question) believe that the sign is positioned in good view of motorists stopped at the crossing.

The findings presented in this report support the following conclusions:

- The STC warning sign demonstrated favorable results, especially during the second 30-day "After" testing period. During this period, the number of illegal pedestrian movements and risky driver behavior was reduced by more than 80 percent compared to the "Before" testing period.
- A significant reduction of 26 percent was noted in the frequency of vehicles that crossed the tracks after the first light rail vehicle cleared the crossing while the gates were ascending but have not reached the full upward position, and before the gates descended again upon activation of the circuits by the second coming train.
- The STC sign demonstrated that motorists may have been more cautious and aware of an STC presence in the second 30-day "After" test period than the first 30-day "After" test period. The number of motorists who crossed the gate line and immediately backed off after realizing an STC incident was occurring increased by 100 percent. This phenomenon needs more investigation due to the small number of these incidents (4 prior to installation, 6 in the first "After" period, and 8 in the second "After" period).
- The STC sign was well received and understood by motorists.
- Although the STC sign demonstrated an effective means to reduce risky behavior, there were still several occasions where drivers displayed risky behavior (i.e., attempting to cross tracks after the first track circuit activation was cleared).
- This project provided the MTA engineering and maintenance staff with more insight about drivers' risky behavior; such information will be very useful in the future planning and design of similar facilities.
- The project provided positive public relations with the motoring public through the MTA's broad coverage of this safety demonstration project. The project was televised and demonstrated on Baltimore local TV channels 11 and 13, was published in local newspapers, and was discussed on local radio stations.
- Motorist confusion about the STC and the activation and deactivation of the warning and protection devices is governed by a period that is approximately 10 seconds long, which is the length for the protection gates to ascend into a full vertical position prior to a second train activation.

In view of the above findings, and in light of the many responses that were received from motorists, it is determined that the STC system is effective and can reduce risky behaviors and improve the overall traffic safety at the Timonium Road crossing. Therefore, it is suggested that the next edition of the *Manual on Uniform Traffic Control Devices* include a requirement for an STC warning system at all highway-rail intersections that experience STC.

APPENDIX A: PHOTOGRAPHS

Figure A-1. Looking at Light Rail Transit (LRT) Grade Crossing on Timonium Road, from west leg.

Figure A-2. Looking at LRT Grade Crossing on Timonium Road, from east leg.

Figure A-3. LRT Double Track Crossing, looking north.

Figure A-4. Vehicles stopped while gate arm is descending.

Figure A-5. Overhead LED blank-out sign with warning flasher and CCTV for data recording.

Figure A-6. Pedestrian signals and warning sign — south leg.

APPENDIX B: SECOND TRAIN COMING WARNING SIGNS

Figure B-1. One frame of the entire prototype message.

Figure B-2. Text message: "WARNING."

Figure B-3. Text message: "2nd TRAIN COMING."

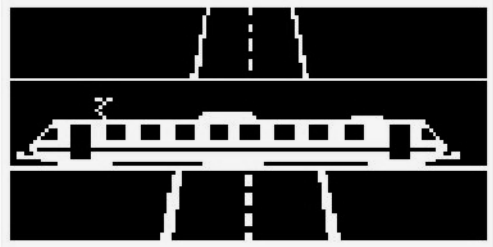


Figure B-4. Animation sequence.

APPENDIX C: MTA SIGN MESSAGE SELECTION SURVEY

Questionnaire

The Mass Transit Administration is planning to install and test active warning signs, such as the sign shown here, at light rail grade crossings in the Baltimore area to improve safety to the motoring public.

Assume you are the driver stopped at a railroad crossing and observe the warning sign message as shown here, what choice would you select that conveys what is shown on the sign.

Sign Display A

☐ Sign message and graphical illustration indicate that I should not travel through the intersection because a train from any direction is about to cross the intersection.

☐ Sign message and graphical illustration indicate that I should not travel through the intersection because a train has just passed the intersection and a second train is about to arrive at the intersection from the other direction.

☐ Sign message and graphical illustration indicate that it is okay to travel through the intersection because the trains have already crossed the intersection.

☐ Other: (Explain) _____
_____

Sign Display B

☐ Sign message and graphical illustration indicate that I should not travel through the intersection because a train from any direction is about to cross the intersection.

☐ Sign message and graphical illustration indicate that I should not travel through the intersection because a train has just passed the intersection and a second train is about to arrive at the intersection from the other direction.

☐ Sign message and graphical illustration indicate that it is okay to travel through the intersection because the trains have already crossed the intersection.

☐ Other: (Explain) _____
_____

Sign Display C

☐ Sign message and graphical illustration indicate that I should not travel through the intersection because a train from any direction is about to cross the intersection.

☐ Sign message and graphical illustration indicate that I should not travel through the intersection because a train has just passed the intersection and a second train is about to arrive at the intersection from the other direction.

☐ Sign message and graphical illustration indicate that it is okay to travel through the intersection because the trains have already crossed the intersection.

☐ Other: (Explain) _____
_____

Name _____ Date _____

Answer to the Question

The second choice under each of the three sign displays is what the MTA is intending to convey to the traveling public.

If you believe that the sign messages and graphical illustrations, as shown here, do not convey the intended message properly then what do you suggest to improve the sign warning display, i.e. message and graphics.

Name _____ Date _____

APPENDIX D: DETAILS OF ELECTRONIC CIRCUITS

SIGNAL CONTROL CIRCUITS: REVIEW OF TYPICAL GRADE CROSSING GATE OPERATION

In order to discuss the timing requirements for the STC circuitry, it is necessary to review the operation of typical grade crossing train detection circuitry. Figure 2 on page 44 illustrates the Timonium Road grade crossing. Note the two tracks intersecting with Timonium Road, and that each track contains two track circuits. The purpose of track circuits is to detect the presence of trains through the electrical connection between the train wheels via the axle.

The two track circuits consist of an approach track circuit and a second track circuit. Observe that the two track circuits overlap corresponding with the roadway intersection. The area where they overlap is called the crossing island. Note on **TRACK 1** that the approach track circuit detects southbound trains at **1780ft** from the intersection. At a distance of 1780ft, a train traveling at 50 MPH is 24 seconds away from the intersection. About 3 seconds after a train is detected, the gates begin to descend and reach the "fully down" position within 10 to 15 seconds. The gates reach their fully down position at least 5 seconds before the train reaches the crossing island.

When the train passes by the intersection, it leaves the crossing island and is detected only by the second track circuit. At the point when the train exits the island, the gates begin to go back up and within 8 to 10 seconds the gates reach their vertical rest position. The second track circuit detects the train until it travels 528ft from the intersection. At that point, the train is considered completely clear of the grade crossing. At 50 MPH, it takes 8.2 seconds until the last axle of a single car light rail train reaches the 528ft-clearance distance. A two-car light rail train takes 9.5 seconds and a three-car light rail train takes 10.8 seconds to clear the perimeter of the crossing.

It is important to note that most drivers do not wait until the gates reach their fully vertical position before they resume their passage. Within about 3 seconds after the gates begin to go up, most drivers resume their travel through the crossing. The MTA has data that confirms this unfortunate, commonplace, and illegal behavior.

SECOND TRAIN COMING (STC) ELECTRONICS OVERVIEW

Refer to Figure D-1 (SECOND TRAIN COMING SYSTEM BLOCK DIAGRAM). Note the three wayside buildings in which the electronics are located. Wayside Instrument Case (WIC) 626N has a vital relay circuit (STC) that

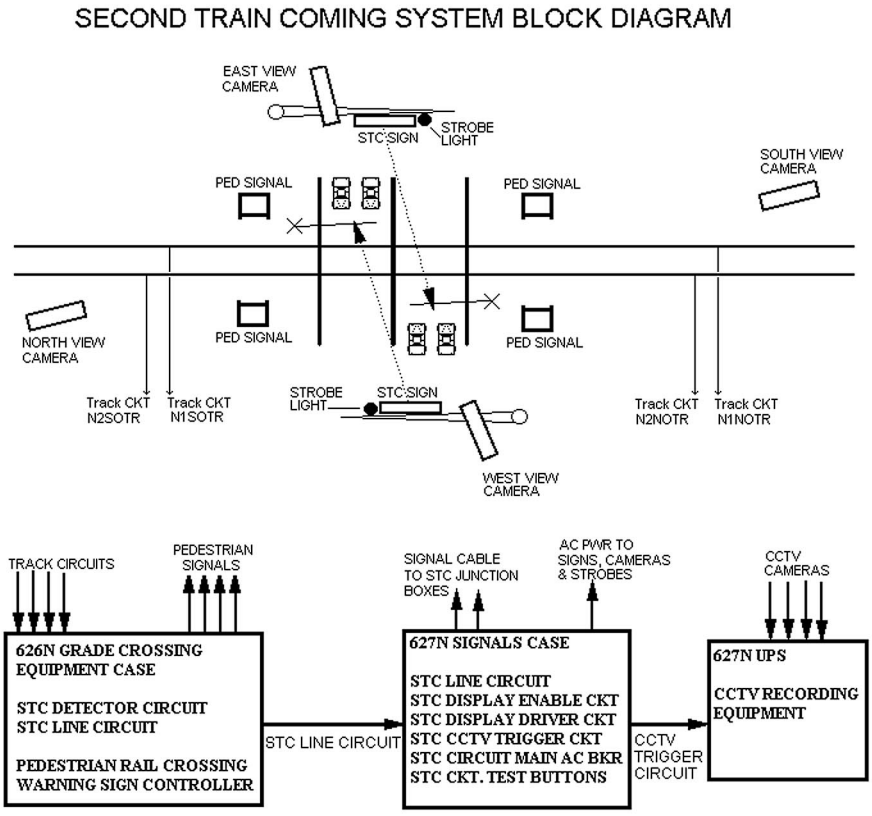


Figure D-1

senses the second train coming event based on the grade crossing track circuits. A vital circuit at WIC626N controls a repeater relay (STCP) at WIC627N. The electrical connection between WIC626N and WIC627N utilizes existing wires within the MTA's express cable. At WIC627N, two vital relays (STCP, STCDRV) serve to activate the STC graphic signs and strobe lights that are mounted on both grade crossing cantilevers. The same circuitry also triggers the alarm signal to the CCTV recording equipment located inside of the 627N UPS shelter.

Activation of the STC signs and strobe lights involves switching 24 volts DC to a pair of control relays located inside junction boxes nearby each STC sign. One of the control relays switches 120 volts AC to the strobe light. The other control relay provides a dry contact closure to a set of message activation contacts for the STC sign.

The CCTV recording equipment at UPS627N consists of a VCR and analog multiplexer that interfaces to four external CCTV cameras. The design of the CCTV equipment is such that the cameras always operate and the recording equipment is set to record during alarm conditions. When the CCTV equipment receives an alarm signal due to an STC event, the CCTV VCR will record the four cameras until the STC event no longer exists.

Electrical power distribution for all STC-related equipment is fed from location 627N via a 30A utility feed. At location 627N, a power line conditioner and lightning arrestor have been installed to provide protection and clean AC power to the STC signs, strobe lights, and CCTV cameras. A 30A breaker is present in the STC AC distribution circuit at location 627N.

Conduits and junction boxes have been installed to accommodate interconnection between all STC equipment. Refer to Figure D-2 for conduit layout. An existing spare conduit has been used between WIC627N and the UPS627N to provide interconnection for CCTV and STC wiring.

DETAILED DESIGN OVERVIEW

1. Second Train Coming Typical Incident

Refer to Figure 2 on page 44, which illustrates a typical second train coming incident. Observe the first train (SOUTH OF CROSSING) that is traveling north on Track 2. Note that as the first train approaches the crossing, it first occupies approach circuit N2SOTR then it occupies the second track circuit N2NOTR. The STC incident takes place

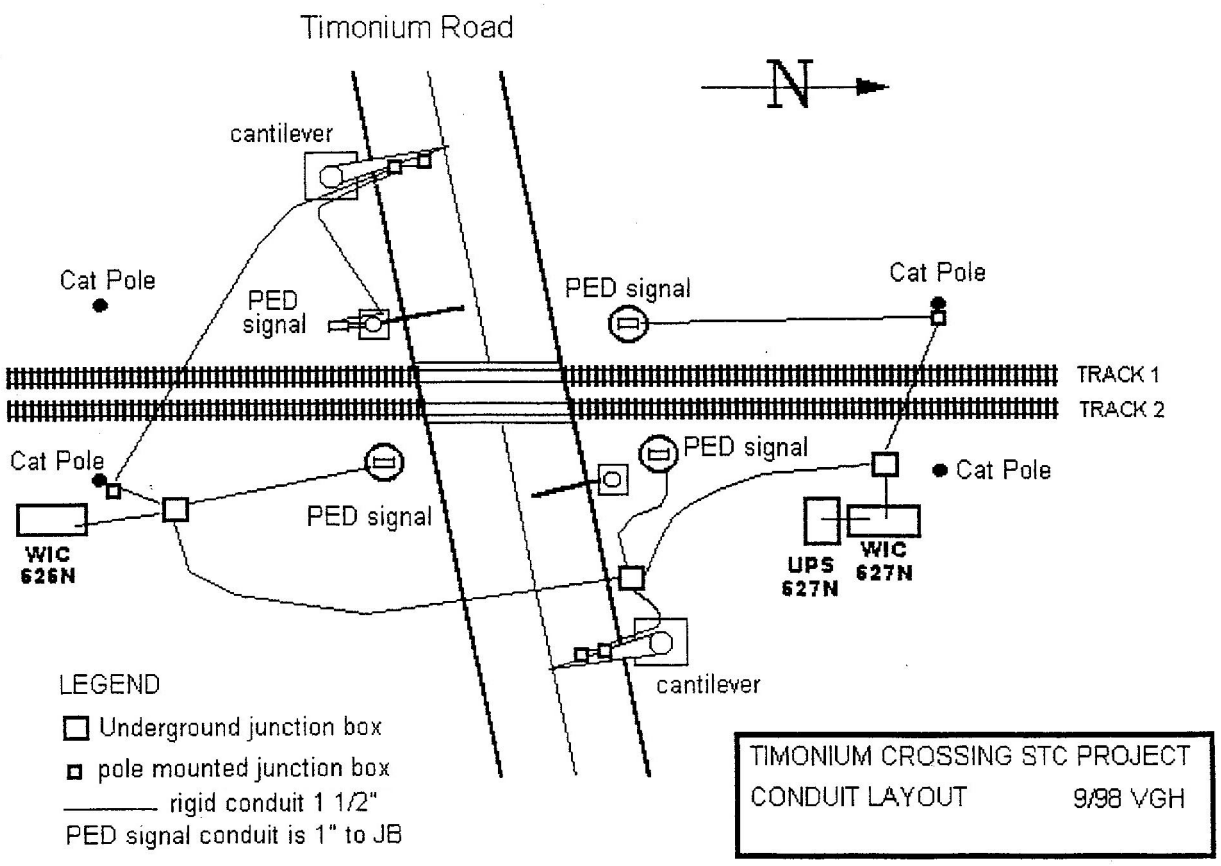


Figure D-2

when a second train activates the southbound approach circuit, N1NOTR, while the first train is traveling upon either track circuit N2SOTR or N2NOTR. When two trains are detected in the area of the grade crossing, the STC circuit in WIC626N will detect this condition. Based on the above example, it can be seen that the second train coming condition exits when occupancy is detected from a northbound train on track circuits N2SOTR or N2NOTR along with occupancy on approach circuit N1NOTR. For southbound trains, an STC incident could occur while the southbound train occupies either track circuit N1NOTR or N1SOTR while a northbound train enters its N2SOTR track circuit.

2. STC Detector Circuit

Figure D-3 depicts the new vital relay circuit STC inside of WIC626N. Observe the track circuit back contacts in the STC relay coil circuit. When a train occupies a track circuit, the corresponding track circuit relay will de-energize and the relay back contacts will close. Relay STC will energize when either relay N1SOTR OR N1NOTR de-energizes AND relay N2SOTR OR N2NOTR de-energizes. Either of the STC incidents as described in the above paragraph would produce these results. When relay STC energizes, it becomes latched (or "sticked") via the approach track circuit upon which the second train is coming (N1NOTR or N2SOTR). This is necessary to permit the STC warning to continue to operate even if the first train moves clear from both of its track circuits before the second train arrives at the crossing.

3. STC Line Circuit

Refer to Figure D-4; when relay STC energizes, its normally open contacts 1H, 1F and 2H, 2F will close and provide 12 Vdc (B12B) onto line circuit STCP. Line circuit STCP controls a new vital relay STCP, located inside WIC627N. The existing signal's express cable provides the interconnection between WIC626N and WIC627N. Figure D-5 illustrates the new vital relay circuitry inside of WIC627N. Relay STCP will energize when 12 volts is present on line circuit STCP. Note also the presence of the STCTEST buttons. When both buttons are pressed, relay STCP will energize to activate the STC warning system. Releasing the buttons deactivates the test.

4. STC Display Driver Enable Circuit

Figure D-5 illustrates relay circuit STCDRV that is energized via STCP contacts 1H, 1F when relay STCP is energized. Relay STCDRV is a magnetic blowout relay that is designed to minimize the arcing associated with the switching of DC power. When relay STCDRV energizes, it enables the STC DISPLAY DRIVER CIRCUIT shown in Figure D-6.

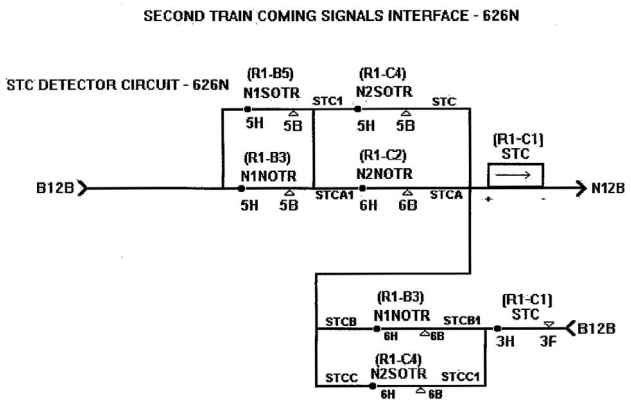


Figure D-3

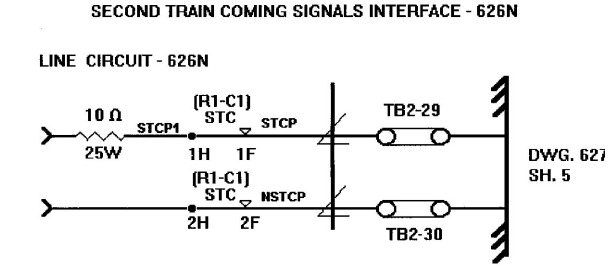


Figure D-4

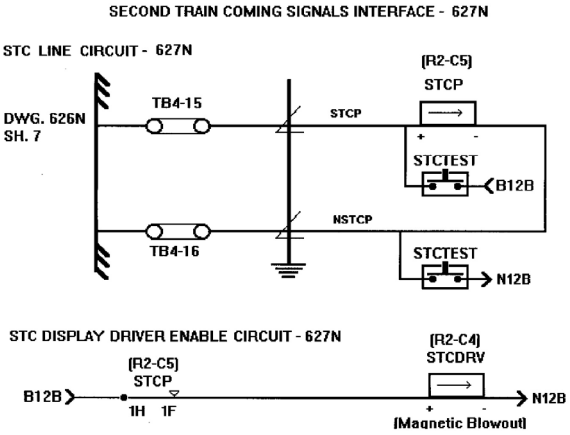


Figure D-5

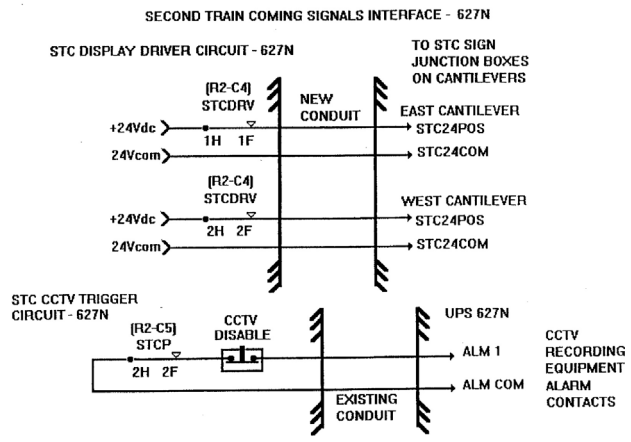


Figure D-6

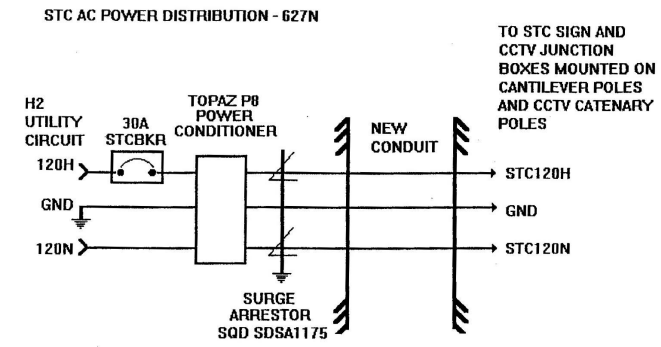


Figure D-7

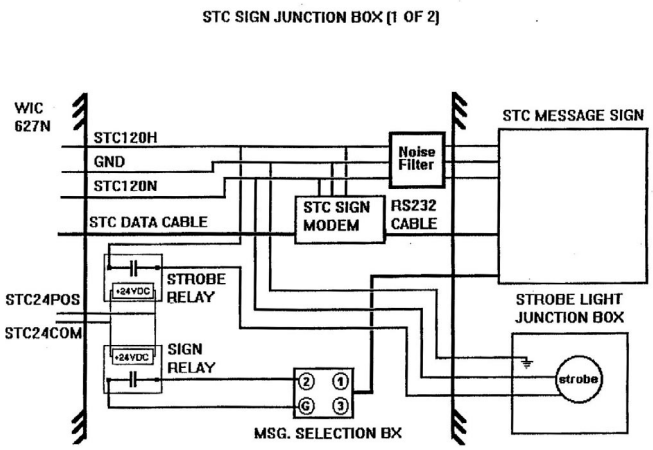


Figure D-8

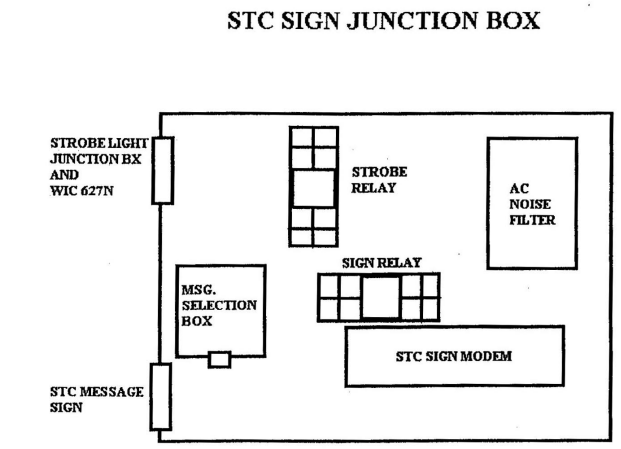


Figure D-9

5. STC Display Driver Circuit

Figure D-6 illustrates the circuitry that interfaces WIC627N with the two STC sign junction boxes. Contacts 1H, 1F and 2H, 2F of relay STCDRV are used to switch +24Vdc to each of the two STC junction boxes. When +24Vdc is supplied to the junction boxes, the STC warning signs and strobe lights are activated.

6. STC CCTV Trigger Circuit

Figure D-6 illustrates the alarm circuit that is used to trigger the CCTV recording equipment inside of the UPS 627N shelter. Note contacts 2H and 2F of relay STCP that will close when relay STCP energizes. The alarm circuit terminates onto the normally open alarm contacts of the VCR inside the UPS 627N shelter. A CCTV DISABLE button is available to prevent VCR recording when performing maintenance testing of the STC warning system. When pressed, the disable button prevents alarming the VCR until it is released.

7. STC AC Power Distribution Circuit

Figure D-7 depicts the AC power distribution for the STC system. The 30A H2 utility circuit at WIC627N is used to supply STC AC power. Power is distributed to the STC junction boxes via a 30 circuit breaker, a power conditioner, and a surge arrestor. The AC power is further distributed from the junction boxes out to the CCTV cameras and STC signs.

8. STC Sign Junction Box

Figure D-8 shows the electrical circuitry within each junction box and Figure D-9 shows the physical layout of the junction box controls. The 120 VAC electrical power from WIC627N is supplied to the STC message sign through an EMI noise filter. The 120 VAC is supplied to the strobe light junction box via the strobe control relay. In addition, the 120VAC powers the STC sign modem. The modem is one of two modems used to provide reprogramming capabilities for each STC sign. The second modem for each STC sign is located inside of WIC627N. The modem in the STC junction box interfaces to the STC sign via an RS232 cable. Programming of either sign involves connecting the STC sign programmer (a lap-top computer with special software) to the appropriate modem within WIC627 and uploading the new message. The two control relays within the STC junction box are used to switch 120 VAC to the strobe light and to provide a dry contact closure to the message selection box. The message selection box interfaces with the STC sign and provides contacts for activating the preprogrammed messages. Contacts G and 2 are wired to select the STC warning message upon receipt of a dry contact closure. For maintenance purposes, shorting pins G and 3 can access a test message.

9. STC Variable Message Sign

The STC signs are manufactured by Action Media Technologies (AMT) of Chatsworth, California. Each of the 64x128 STC signs consists of an industrial hardened PC type microcomputer (AIO main board), a 64x128 matrix scan board, 16 driver boards with high intensity amber light emitting diodes (LEDs), and two 5 VDC power supplies. The components are housed within an aluminum case designed for outdoor use. The case is painted gloss black with a LEXAN faceplate to protect the LEDs. The LEDs are spaced with 0.3-in. center spacing and their intensity varies under the control of an automatic circuit that compensates for day or night viewing. The LEDs in the sign utilize Hewlett Packard's proprietary AlInGaP LED technology.

The operating system for the sign is MS-DOS in conjunction with AMT's proprietary sign software. When the sign is provided 120VAC power, it boots up and automatically configures itself to await message selection. When the sign detects contact closure associated with one of its message selection contacts, it displays the appropriate message. The message display will recycle repeatedly until the contact closure is removed. File storage is accomplished through the use of FLASHRAM, as opposed to a mechanical hard drive. The AIO main board has interface connection ports for communication and message selection. The communication port is an RS232 interface that allows the transfer of files from an external computer (sign programmer) over to the STC sign. The message selection port provides 3 contacts that are used to activate one of the 3 messages stored within the sign's non-volatile memory. Messages consist of animation files (FLI files) created using a graphics package known as AutoDesk Animator. The software is designed to integrate text and moving graphics to create a multi-frame graphic file. When the graphic files are displayed, the frames of the message are displayed such that the image appears to be animated. Once the graphic files are created using AutoDesk Animator, a communications program provided by AMT is used for transferring message files into the sign.

The mounting of the signs onto the cantilevers is such that the signs can be focused to project their display in the direction of the intended viewer. The MTA designed a special mounting adapter to affix the signs onto the cantilever structures. The adapter was fabricated using materials acquired from the cantilever's manufacturer, SAFETRAN. MTA's engineering consultant, Sabra Wang & Associates, performed a stress load analysis to certify the mounting as being safe.

10. Pedestrian Walkway Signal Control Circuit

An ancillary goal of the STC project was to provide additional safety equipment to govern pedestrian movements across the railroad tracks. At each corner of Timonium crossing, pedestrian WALK / DON'T WALK signals (PED signals) have been installed. The signals are capable of displaying either a walking man icon or a hand icon to govern pedestrians who are crossing the tracks at the grade crossing.

Figure D-10 illustrates the system that controls the PED signals. The system interfaces with the railroad grade crossing circuitry and consists of a controller and a vital relay (WALK) circuit, which are located inside WIC626N. Control of the PED signals is based upon the operation of the WALK relay. When the WALK relay is energized, the PED signals show their walking man (WALK) icon. When the WALK relay de-energizes, the PED signals begin their DON'T WALK cycle. The cycle begins with a flashing hand (DON'T WALK) icon and is followed by a steady illuminated hand icon. The WALK relay is controlled by either the PED signal cycle test button (for maintenance) or by the grade crossing's XGNP relay. The test button is used to observe and adjust the operation of the DON'T WALK cycle. The XGNP relay is part of the crossing gate circuitry and, when energized, indicates that the gates are in their full vertical position. The XGNP relay de-energizes when a train is detected approaching the grade crossing. This coincides with the activation of the flashing lights, the bell, and the descent of the gate arms. The XGNP relay does not reenergize until after the train has passed and after the gates have reached their vertical position.

Note the presence of the **SLOW RELEASE CIRCUIT** in conjunction with the WALK relay. The *Manual on Uniform Traffic Control Devices* (MUTCD) specifies that the WALK interval of a pedestrian signal must be at least 4 seconds. The purpose of the slow release circuit is to delay the WALK relay from de-energizing for 4 seconds after the XGNP relay de-energizes. The operation of the slow release is as follows: When contacts 1H and 1F of relay XGNP close, 12 VDC is supplied to both the WALK relay coil and to capacitor C1. Capacitor C1 rapidly charges to 12V through the RSURGE resistor and through diode D1 (*note that D1 allows C1's charging current to bypass the RDELAY resistor)*. When contacts 1H and 1F of relay XGNP open, 12 VDC is maintained for 4 seconds on the coil of relay WALK

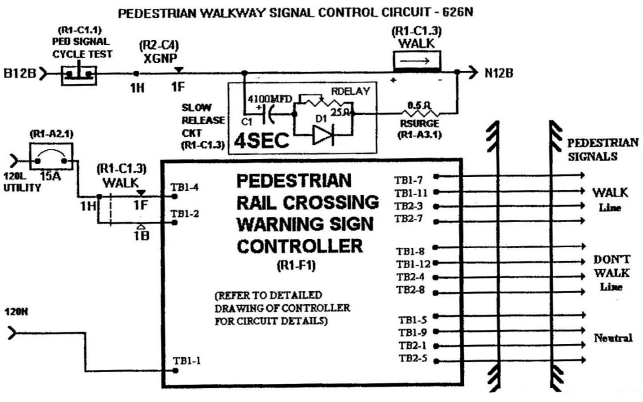


Figure D-10

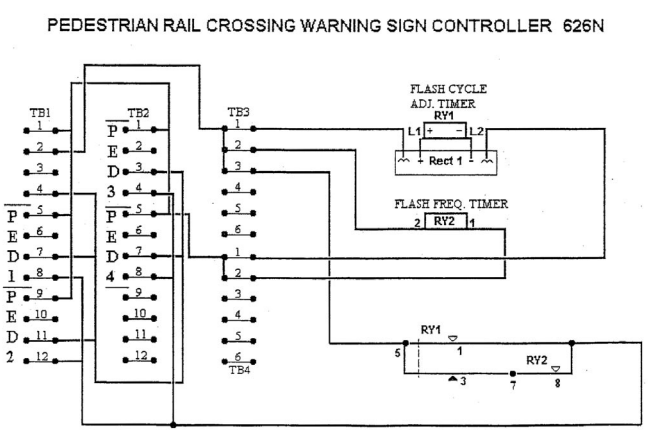


Figure D-11

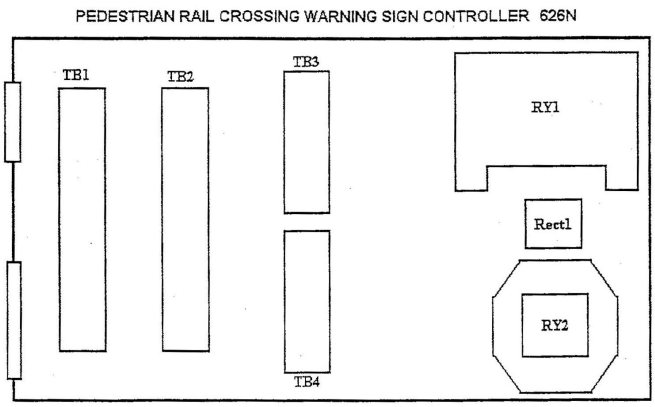


Figure D-12

via the charge stored in C1. It takes about 4 seconds for C1 to discharge through the RDELAY and RSURGE resistors. When C1 discharges sufficiently, the WALK relay will de-energize. Note that the purpose of the RSURGE resistor is to limit the charging current associated with capacitor C1.

The remaining PED signal control is accomplished within the **PEDESTRIAN RAIL CROSSING WARNING SIGN CONTROLLER** as illustrated in Figure D-11. The controller is responsible for implementing the timing relative to the DON'T WALK cycle. The MUTCD specifies that a PED signal must flash its DON'T WALK icon long enough for pedestrians to vacate the walkway. The timing of the flash interval is based upon how long it takes a pedestrian to cross the entire walkway from sidewalk to sidewalk. At the Timonium Road crossing, the walkway distances are 47 feet and 38 feet. The MUTCD specifies a pedestrian's speed as being 4 feet per second. Therefore, 13 seconds was chosen as the flash interval to be well within the MUTCD guidelines. When the WALK relay de-energizes, 120VAC is switched from its 1F contact to its 1B contact as shown in Figure D-10. This causes 120 VAC to be applied to TB1-2 of the controller. Figure D-11 further illustrates terminal strip TB1 within the controller. Note that TB1-2 is wired to TB3-1 and to rectifier **RECT1**. Observe that the **FLASH CYCLE ADJ. TIMER RY1** receives 120 VDC via **RECT1**. Relay timer RY1 delays the closing of its contacts until its 13-second time delay expires. Note RY1's contacts 5 and 3 on Figure D-11, which provide a path for 120 VAC to illuminate the DON'T WALK icons during the flash interval. When the 13-second time expires, relay RY1 energizes and RY1's contacts 5 and 1 provide the 120 VAC to illuminate the DON'T WALK icons in the steady state. The flashing of the DON'T WALK icons is accomplished via contacts 7 and 8 of **FLASH FREQ. TIMER RY2**. Relay RY2 opens and closes its contacts slightly less than once every second. Relay RY2's flash time is adjustable and is set to provide an appropriate on/off time for the DON'T WALK icons. Figure D-12 details the component layout of the controller.

The PED signals consist of McCain Traffic Supply series 1000 single head incandescent pedestrian signals. The signals use 68W traffic signal bulbs powered by 120 VAC via the PED controller inside of WIC 626N. The signals are side mounted onto 10-foot masts that stand upon breakaway bases. The bases are set upon 6-foot-deep concrete foundations. An electrical ground rod is installed and connected to each signal base. The materials used for the signals, masts, bases, and foundations meet the requirements as set by the Maryland State Highway Administration for such equipment.

APPENDIX E: MOTORIST SURVEY

MOTORIST SURVEY

Second Train Coming Warning Signal Demonstration
Federal Transit Administration Grant Project

The MTA is testing a new warning system for the Federal Transit Administration to use at highway grade crossings. The device, called the Second Train Coming (STC) warning system, is currently being tested on Timonium Road at the Light Rail crossing near the State Fairgrounds.

The purpose of the warning system is to alert motorists who are stopped at the crossing that a second train is coming from the opposite direction. Message signs and strobe lights are mounted above the roadway in the view of drivers whose vehicles are stopped at the crossing.

Here is how it works:

1.When a train is approaching the grade crossing, motorists will see the crossing gates descend and will stop their vehicles at the gates. If, during this time or when the gates begin to rise, another train approaches the crossing from the opposite direction, the STC warning system will be activated.

2.When activated, the strobe lights will flash and the message signs will display a warning followed by an animated graphic showing two trains moving through the grade crossing. The warning will continue until both trains are clear of the crossing. This new system serves as an additional warning and does not affect the operation of the gates, flashing red lights, or bell.

Please answer the following questions, then fold, tape and deposit in a mailbox for return to the MTA by December 11th.

Your response is greatly appreciated.

---

1. If you have seen the STC system in operation, did it effectively warn you that a second train was coming from the opposite direction ?

☐ **yes** ☐ **no** ☐ **did not see it in operation**

2. Do you feel the new warning system will increase the safety awareness of motorists?

☐ **yes** ☐ **no**

3. Is the message sign positioned in good view of motorists stopped at the crossing ?

☐ **yes** ☐ **no**

4. Please express any thoughts you have concerning this new MTA project.

For more information, visit the MTA's STC web site at:
http://www.bcpl.net/~vhartsoc/stcweb.htm

APPENDIX F: PROJECT SCHEDULE AND COST

Second Train Coming
Project Schedule

- Award of grant to MTA (3/97)
- Engineering design completed (8/97)
- Specifications for signs completed (10/97)
- Delivery of signs (5/98)
- Installation of signs (8/98)
- Data collection period (9/98 to 12/98)
- Analysis and draft final report completed and submitted to FTA (2/99)

Project duration: Approximately 2 years

Second Train Coming
Project Expenses

COST	PURPOSE OF EXPENDITURE
$ 36,665	Provide and install 4 CCTV cameras & recording equipment & remote playback station
$ 28,764	Install conduits under road and trackway and up aerial mounting structures and run cables as-needed for CCTV system installation
$ 30,000	Provide 2 active-matrix high-intensity 64 x 128 LED signs, strobe lights, modems, mounting hardware, and programming software
$ 2,553	Purchase portable sign programmer from sign manufacturer
$ 2,240	Purchase spare parts kit for signs
$ 562	Purchase printer and CD-ROM for playback station
$ 355	Purchase extra data pack for playback station
$ 1,200	Purchase cantilever mounting fixtures from Safetran
$ 4,000	Provide 4 pedestrian crosswalk signals with bases, masts, and side-mounting hardware
$ 1,500	Provide a 1/87 scale model of Timonium Grade Crossing with functional LRV models for training/presentation purposes
$ 15,475	Layout and install the STC signs and pedestrian signals
$ 3,785	Public survey of 10,000 residents
$ 30,355	Consulting / engineering services from Sabra, Wang & Associates
$ 2,000	Miscellaneous items used to construct the signal system interface, the PED signal controller, the site-located telephone circuit, as well as copying and photography expenses, etc.
$ 40,546	MTA employee time charged to project (union and management)

Total estimated expenditures: $200,000