Los Angeles Metro Blue Line Light Rail Safety Issues

LINDA MEADOW

Light rail transit systems have become popular because of their relatively low cost; ability to operate both on and off city streets, with intermediate capacity for transporting passengers; and frequent stops in urban areas. Most LRT systems operate portions of their systems in city streets, within median strips and in transit malls. Successful operation of LRT systems in the urban environment depends on integrated light rail and traffic signal controls. The operation of LRT systems in shared right of way presents a situation for accidents because of other users (motorists, pedestrians, bicyclists) in the right of way. Many safety problems are the result of motorists' and pedestrians' failure to obey or understand traffic controls. The Metro Blue Line (MBL) is a 22-mi LRT system that operates from downtown Los Angeles to the city of Long Beach. Approximately half of the MBL route runs parallel to an existing Southern Pacific railroad right of way, travels at speeds of up to 55 mph, and traverses 28 at-grade street crossings in areas of high traffic volume. The MBL Grade Crossing Safety Program was initiated in March 1993 to evaluate various ways to discourage or prevent illegal movements being made by vehicles at grade crossings that are causing train and automobile accidents. The safety program includes four elements: enforcement, engineering, legislation and bilingual public education.

Light rail transit (LRT) systems exist throughout North America in 18 cities in the United States and Canada. LRT systems have become popular because of their relatively low costs and ability to operate both on and off city streets, with intermediate capacity for transporting passengers, and frequent stops in urban areas. Many LRT systems operate portions of their systems in city streets in mixed traffic, within median strips, and in transit malls. Most systems have some grade crossings.

Design, construction, and operation of LRT systems requires a partnership between the transit agency, contractors, and the city and county traffic officials. Successful operation of LRT systems in the urban environment depends on integrated light rail and traffic signal controls. In addition, light rail crossings must be engineered in accordance with established safety principles and guidelines. The California Public Utilities Commission (CPUC) regulates light rail safety in California through a series of general orders. Some other states have state oversight agencies with similar safety requirements.

FTA has issued a notice of proposed rulemaking that will require all states to have safety oversight agencies for rail fixed guideway systems (*1*).

Operation of LRT systems in shared right of way (interaction with motorists, pedestrians, bicyclists) presents a situation for accidents and congestion. Collisions involving light rail vehicles and other users of shared right of way can result in significant safety problems. Many safety problems are the result of motorists' and pedestrians' failure to obey or understand warning devices and traffic controls.

Grade separation, where the LRT system operates above ground in a depressed guideway or subway, is the safest form of light rail operation. However, since grade separations are very costly to build, many properties do not choose this option.

LRT SAFETY ISSUES

Transit officials throughout the United States and Canada are working to develop effective treatments to reduce the number of collisions involving LRT trains. ITE recently conducted a survey of 17 LRT operating properties. Survey responses indicated a wide range of safety problems and areas of concern related to LRT operations in city streets and on reserved rights of way with at-grade crossings. The ITE survey identified the following:

- Motorist disobedience of traffic laws;
- Crossing equipment breakage and malfunction;
- Traffic queues blocking crossings;
- Vehicles exiting driveways stopping on tracks;
- Vehicles turning from streets running parallel to the tracks;
- Motorists running around closed crossing gates;
- Vehicles making left or U-turns in front of trains or stopping on tracks;
- Pedestrian conflicts at station areas and crossings;
- Light rail vehicles (LRVs) blocking street and pedestrian crosswalk areas at crossings;
- Motorist confusion over traffic signals, LRT signals, and signage at intersections; and
- Unusual crossing configurations.

The Transit Cooperative Research Program (TCRP), established under FTA sponsorship in 1992, includes FTA, the National Academy of Sciences, and the Transit Development Corporation. TCRP is sponsoring a 2-year program to improve the safety of LRT operations in shared right of way. The contractor selected for the program will investigate the effectiveness of passive and active signage currently in use at LRT properties; traffic signalization, including LRT indications; pavement markings; geometric improvements, including channelization and medians; audible warning devices, including bells, whistles, and horns; crossing illumination levels; illumination and marking of LRVs; moveable traffic barriers; applications of advanced technology; enforcement; and public education.

LRT GUIDELINES

Uniformly accepted standards for light rail signals, signs, and pavement markings do not exist anywhere in the world. The Cal-

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ifornia Traffic Control Devices Committee Light Rail Safety Subcommittee recognized the need for uniformity of signs, signals, and markings on roadways and LRT alignments in California. This committee has prepared a draft *Light Rail Safety Manual*, which contains guidelines for light rail signals, signs, symbols, markings, and other information related to the planning, design, and operation of light rail systems. When adopted by the California transit operators in final form, the *Light Rail Safety Manual* will be a primary reference for the design, development and operation of LRT systems.

Part 8 of the *Manual on Uniform Traffic Control Devices* addresses traffic control for railroad-highway grade crossings in the United States (*2*). However, the LRV interaction with motorists, pedestrians and bicyclists with LRT equipment differs from their interaction with traditional railroads because of the high speeds, frequency of service, and other factors. A draft Section 8E on LRT in the United States has been prepared by the Light Rail Task Force of the Railroad-Highway Grade Crossing Technical Committee of the National Committee on Uniform Traffic Control Devices.

METRO BLUE LINE HISTORY

The Los Angeles County Metropolitan Transportation Authority (MTA) is planning over 400 mi of light, heavy, and commuter rail over the next 30 years. Operational lines include the Metro Blue Line (MBL), a light rail line; the MRL, a heavy rail line; and Metrolink, a network of commuter rail lines serving five counties. The Metro Green Line, now under construction, is scheduled to open in 1995.

MBL Overview

The MBL is an LRT system that operates through three cities and unincorporated areas of Los Angeles County, running south from downtown Los Angeles to the city of Long Beach. After 3 years of operation, ridership averages approximately 42,600 passengers a day (Figure 1).

The total route is approximately 22 mi long, with 12 mi of the route (cab signal segment) following an existing Southern Pacific railroad right of way that runs through south-central Los Angeles and Compton. Freight trains use the Southern Pacific tracks that run adjacent to the MBL tracks. Vehicles and pedestrians using at-grade street crossings in this area must cross two MBL tracks as well as one or two Southern Pacific tracks.

On the cab signal route segment MBL trains run under automatic train protection. Train operations are controlled by operators, and speeds are governed by cab and wayside signals. Over this route segment MBL trains travel at speeds up to 55 mph and traverse 28 at-grade street crossings. Many of the grade crossings are located at major streets carrying high traffic volumes. In addition, busy streets run parallel to the tracks at 26 of the 28 grade crossings.

Over street running route segments in downtown Los Angeles and downtown Long Beach (approximately 10 mi), trains are operated according to train T-signals, traffic conditions, and traffic signals. CPUC regulations limit speeds on these route segments to 35 mph. Partial priority is being implemented for certain street running segments.

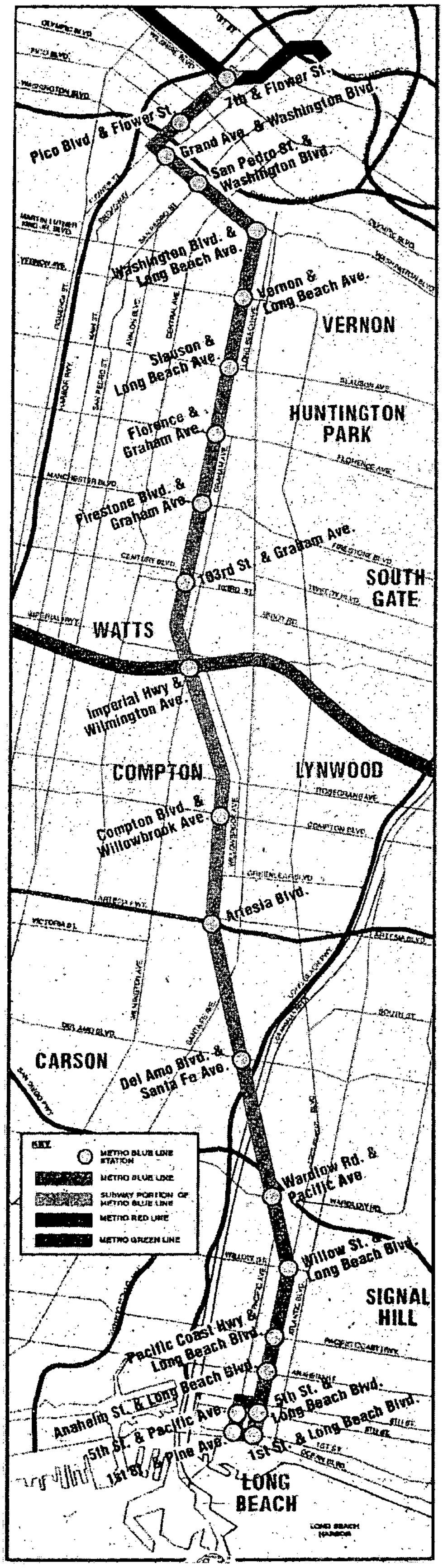


FIGURE 1 MBL map.

Overall, there are 100 grade crossings on the MBL. All of the crossings are protected using appropriate signs and equipment. Crossing protection devices include traffic signals, gates, flashing lights and bells, and stop signs.

MBL Accident Experience

In the 3 years from the opening of the MBL through the end of June 1993, there have been 158 train vehicle and 24 train-pedestrian collisions resulting in 16 fatalities and many injuries. In the MBL's mid-corridor section, motorists have been hit by trains after driving around closed crossing gates against flashing lights and bells. The trains have been moving at high speeds and the accidents have resulted in fatalities and serious injuries. Nearly all of the accidents in street running have been caused by vehicles making illegal left turns because they ignore or do not see red No Left Turn arrows.

Most MBL grade crossings where trains run at high speeds are complicated by several factors that greatly increase the potential for collisions.

Motorists Driving Around Gates

Streets running parallel to the tracks make it possible for motorists making left turns from the parallel streets to drive around lowered crossing gates. A crossing three or four tracks wide makes it easier for motorists to drive around lowered gates in an S pattern.

Multiple Train Tracks

Slower-moving Southern Pacific freight trains run on tracks adjacent to the MBL tracks. Motorists seeing a freight train approaching that is still some distance away might drive around lowered crossing gates without realizing that the gates were activated for an approaching MBL train. More than half of the train-vehicle collisions at crossings on the MBL's cab signal route segment have occurred when a second train, either an MBL or Southern Pacific, has been passing through the crossing.

Frequency of Trains

Trains running as frequently as every 6 min in each direction make it more likely that the gate down times will be extended to allow trains to pass in opposite directions. Soon, the frequency of MBL trains may be increased to as often as every 4 min in order to handle the line's standing-room-only loads in peak periods.

OVERVIEW OF MBL GRADE CROSSING SAFETY PROGRAM

The Los Angeles MBL Grade Crossing Safety Program was initiated in March 1993 to evaluate various means to discourage or prevent illegal movements being made by vehicles at grade crossings that are causing train-automobile accidents. Although the program is focused primarily on evaluating measures to decrease train-automobile accidents, the safety program is also concerned with improvements that will reduce train-pedestrian accidents. MTA is seeking to apply innovative equipment and methods developed for street and highway traffic applications. These engineering improvements will address the unique characteristics of MBL grade crossings and improve public safety.

The safety program includes four elements:

- Enforcement using sheriff's deputies and photo enforcement systems;
- Engineering improvements including use of intelligent vehicle-highway system (IVHS) technologies, warning devices, and street and traffic signal improvements;
- Legislation to establish higher fines and statewide rail safety educational programs; and
- Bilingual public information and safety education.

ENFORCEMENT

Grade crossing enforcement programs include the Los Angeles County Sheriff's Department (LACoSD) Transit Services Bureau traffic detail and photo enforcement systems. MTA contracts with the LACoSD to provide police services for the MBL and to be highly visible on station platforms and trains. This high-level security has served to discourage criminal activity on the trains, at the station areas, and in parking lots.

LACoSD Transit Services Bureau Grade Crossing Traffic Enforcement Program

Starting in June 1992 for a 90-day demonstration period, the Sheriff's Transit Services Bureau established a traffic detail to provide increased enforcement of traffic violations at selected grade crossings. Ten traffic detail deputies were deployed on two shifts a day, 7 days a week, for nearly 13 weeks. The traffic deputies wrote 7,760 citations in 90 days. Because of the success of the program, continuing funding for six deputies was authorized. These deputies have issued more than 11,000 citations in the first year of this effort.

Deputies obtained information from violators on a short survey questionnaire for the first 1,500 violators. The responses indicated that 63 percent of the violators were frequent users of the grade crossing and that 40 percent thought it was safe.

Photo Enforcement Demonstration Program

MTA is conducting a demonstration project involving the installation of photo enforcement systems at four grade crossings along the MBL. Photo enforcement systems involve the use of high-resolution cameras to photograph violators and provide one or more photographs of the vehicle, its license plate, and the driver's face as the basis for issuing a citation. Superimposed onto each photograph is the date, time, and location of the violation as well as the speed of the violating vehicle and number of seconds of elapsed time since the red flashing lights were activated. At crossings with traffic signals, the number of seconds of amber and red signal time are shown.

Photo enforcement technologies have been used—worldwide including in the United States, Europe, and Canada—to capture speed and red light violations. The use of photo enforcement for speed and red light violations has significantly reduced accident rates wherever it has been used.

The U.S. Department of Transportation is funding an evaluation of the effectiveness of photo enforcement at MBL grade crossings. Funding participants include FRA, FHWA, and FTA.

Photo Enforcement Installation in Cab Signal Territory

The photo enforcement cameras are mounted in a bulletproof box on top of an 8–ft pole. A bilingual (English and Spanish) sign tells motorists that photo citations are issued to violators (Figure 2). The camera, located on the southeast corner of the intersection, views the eastbound traffic lanes, monitoring through traffic and left turns from the parallel roadway. Inductive loop detectors buried in a shallow cutout in the road are used to detect the presence of a vehicle when the gate arms begin their descent.

When the violator's automobile crosses the detection loops while the grade crossing signals (gate arms) are in operation, a photograph is taken with data superimposed. Then, approximately 1.2 sec later, another photo is taken that shows the violating vehicle traversing the intersection (Figure 3).

The vendor develops the film, views each photo to see the license plate and image of the driver, and then runs a Department of Motor Vehicles (DMV) check to determine the registered owner of the vehicle. A citation is printed in both English and Spanish and is sent to the registered owner. Citations are issued within 72 hr of the violation.

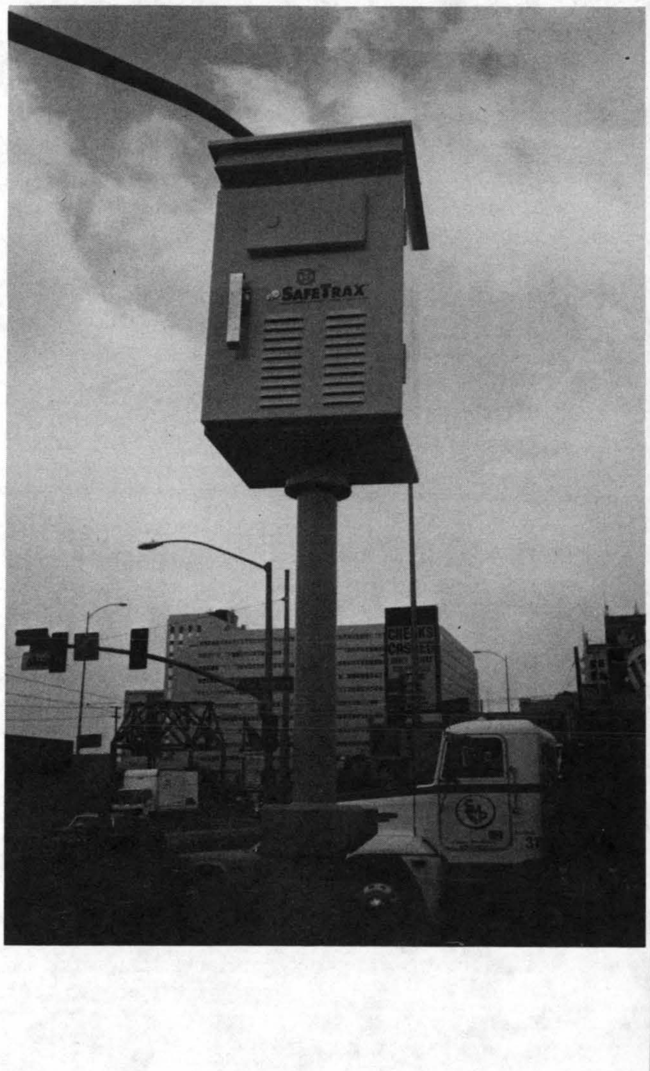
Photo Enforcement in Street Running Territory

In the street running segments, the camera photographs violators making left turns against a red left turn arrow. Street running territory has traffic signals and light rail signals but no rail crossing gates. At the intersection of Los Angeles Street and Washington Boulevard in the city of Los Angeles, inductive loop detectors have been cut into the street to detect automobiles making left turns against a red left arrow indication.

A different approach, using IVHS technology, is being demonstrated in Long Beach, at Willow Street and Long Beach Boulevard. Vehicle detection is being accomplished with video image processing using Autoscope, which includes imaging hardware (video camera), a processor, and software (as seen in Figure 4).

The Autoscope system can detect traffic in many locations within the field of view of the camera. The user specifies the

FIGURE 2 Photo enforcement sign and pole.



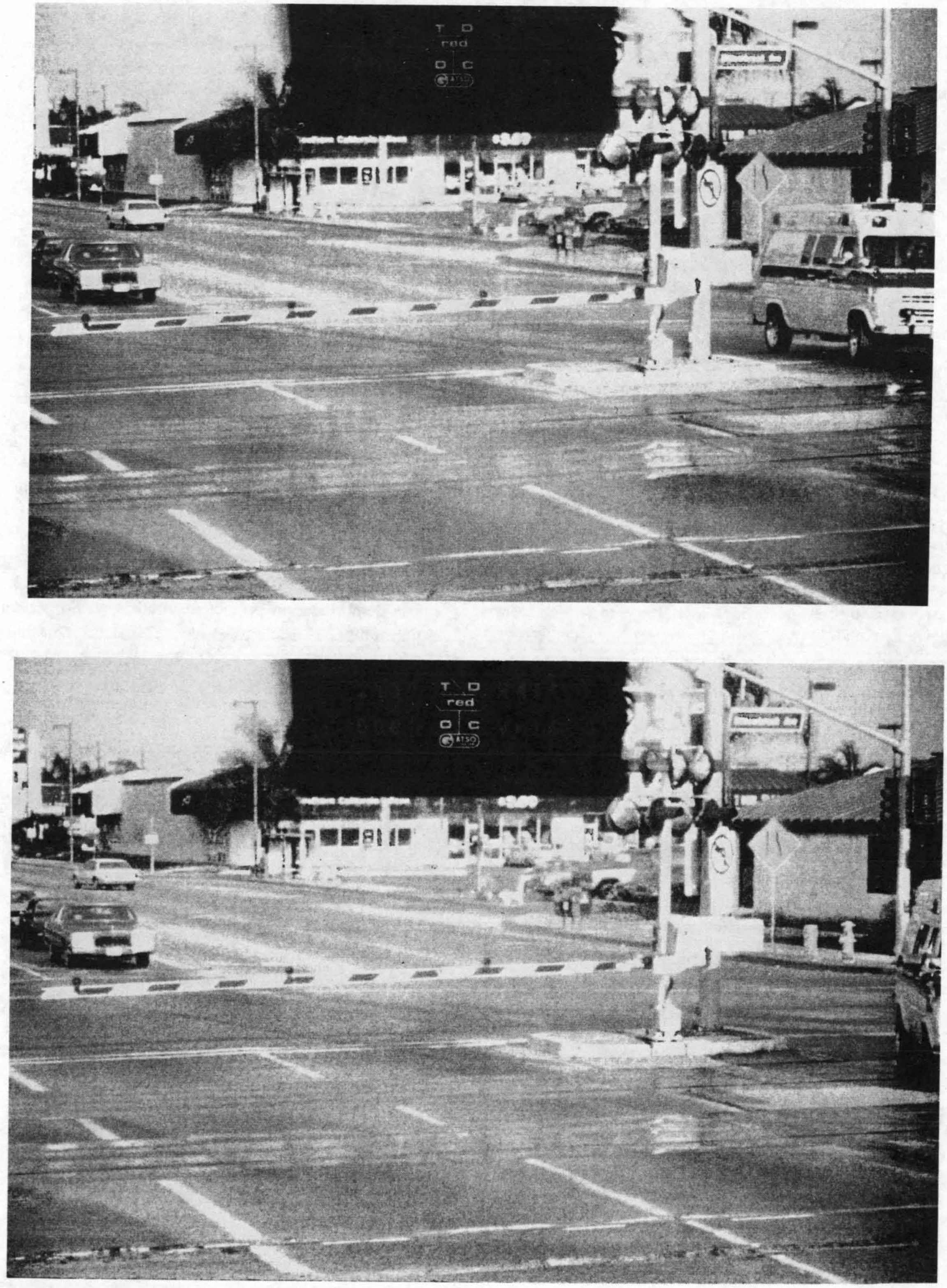


FIGURE 3 Grade crossing violations.

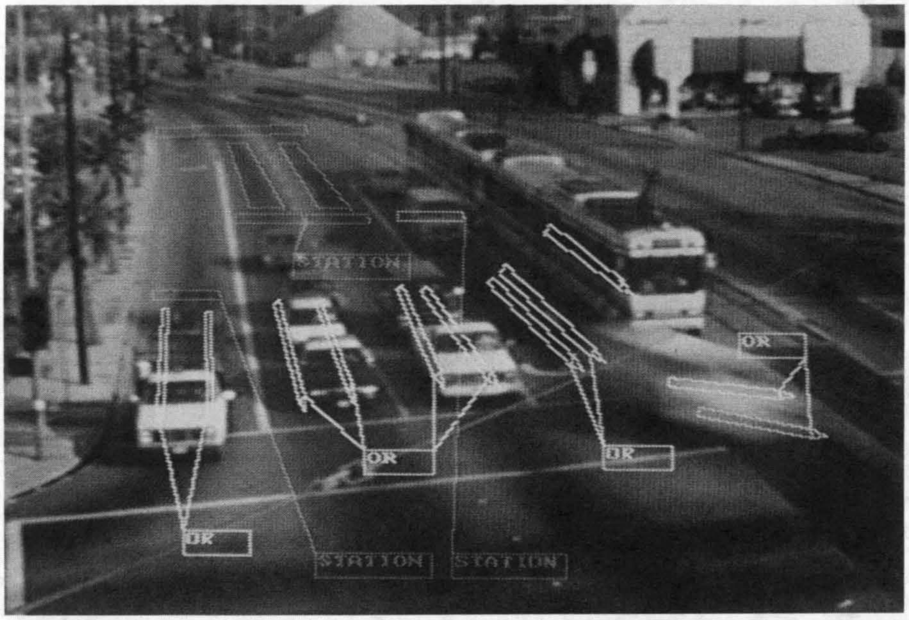


FIGURE 4 Autoscope screen at Long Beach Boulevard and Willow.

locations using interactive graphics. Detection lines are placed along the rail or street on a television monitor that displays the traffic scene. Whenever an automobile or train crosses the detection lines, a detection signal is generated by the device.

Figure 4 presents an image of Long Beach Boulevard as seen by Autoscope. The detector overlay show the vehicle detectors used; those shown in blue (on original screen) have detected a vehicle. The detector on the train is the train detector, and the two across the train track detect a crossing car, as would be desired in a safety application. Detectors can be moved to any location desired in the image, and those shown in brown on the original screen have not detected a vehicle but could do so.

The Harvey Mudd Engineering College is testing the use of a lower resolution digital camera for photo enforcement. Photographs will be transmitted from the camera location to a central processing unit, which eliminates the need for changing film and offline film development.

Results

The photo enforcement program has been extremely successful in terms of reducing numbers of motorists who are violating grade crossings.

Cab Signal Territory The Compton photo enforcement demonstration program was started on November 19, 1992. For the first 2 months, the camera equipment was operated at two crossings in the city of Compton (Alondra and Compton Boulevards, approximately 0.5 mi apart) where poles were installed without any press coverage, public announcements, or signs. During this period, counts were made of the number of violations to serve as a baseline for evaluating the effectiveness of the equipment.

On January 19, 1993, a press conference was held to announce the use of the equipment at the two crossings. Warnings were sent to motorists violating the crossing signals and gate arms when trains were approaching. Signs were installed at the crossing on February 11, 1993. On March 19, 1993, violators were issued citations. The 4-month photo enforcement demonstration project at Compton Boulevard was completed July 19, 1993.

The demonstration project resulted in an 84 percent reduction in the number of violations occurring at the crossing, ending up at 0.15 violations per hour for the last 2 months of the project (Figure 5). Citations were processed by the Compton Municipal Court. During the 4 months of the demonstration project, 548 violations were recorded by the camera equipment at the crossing; 232 citations were issued to violators.

The camera equipment was reinstalled at Compton Boulevard on September 9, 1993, and left there through the end the month to determine if the violation rate had declined further. With a visible sign and camera box, but no citations issued, the violation

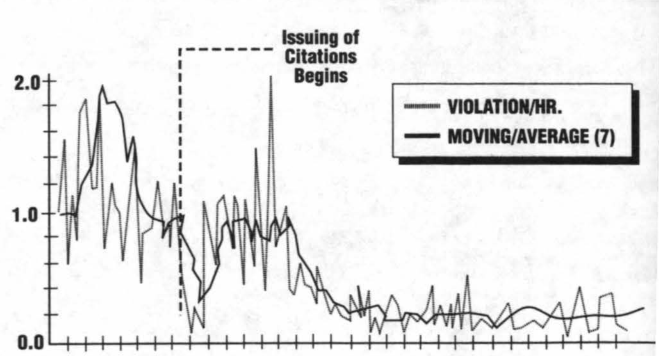


FIGURE 5 Hourly grade crossing violation.

rate declined to one violation every 12 hr (or 0.07 violations per hour).

A 3-month demonstration project was completed at Alondra Boulevard on September 9, 1993. Signs, a camera pole, and cabinet were installed for about 6 months at this location before citations being issued. Grade crossing violations dropped from 0.5 violations per hour in December 1992 to 0.16 per hour in September 1993 when the demonstration project was completed. The rate of violations had declined to approximately 0.28 violations per hour when citations were first issued in June 1993, indicating that a portion of the reduction in grade crossing violations could be attributed to the signs, installation of the pole and cabinet, and enforcement efforts at Compton Boulevard. During the 3 months of the demonstration project, 254 violations were recorded by the camera equipment at the crossing, and 142 citations were issued to violators. The lower number of citations is due to vehicles with no front plate, out of frame, windshield glare, or other factors where the driver is not clearly identifiable.

Twenty percent of the citations issued (79) resulted in calls to the vendor to view the photo. Out of these calls, 26 percent of the motorists who called to make an appointment did not appear. Initial figures on the rate of payment of citations show the payment rate to be approximately the same (50 half) as for citations issued by the Los Angeles Sheriff's Department Traffic Detail.

Because of the success of the photo enforcement demonstration projects, MTA is currently proposing to install cameras at 17 additional grade crossings on the MBL.

Street Running Territory The intersection of Los Angeles Street and Washington Boulevard has a very high number of left turn violations. At this intersection, the camera equipment has been installed to capture left turns made against a red left turn arrow from eastbound Washington Boulevard to northbound Los Angeles Street (toward downtown Los Angeles). The camera has a 150-mm lens which provides photographs showing a closer view of the driver's face and vehicle license plate. Issuance of warning notices began on October 27, 1993. Citations will be issued in mid-January 1994. There was an average of 2.0 violations per hour on weekdays before sign installation. After installation of the signs and mailing of warning notices, the rate of violations has dropped to 1.5 per hour.

ENGINEERING

The MBL was designed and constructed in accordance with industry safety guidelines and standards. Examples include sophisticated train control systems, active warning devices at grade crossings, signage (both regulatory and warning), light rail signals, and pavement markings. However, operating experience has shown the need for additional engineering improvements such as street and traffic signal system improvements, demonstration of four-quadrant crossing gates, demonstration of pedestrian gates, and the testing of a train operator actuated wayside horn system.

Street and Traffic Signal Improvements

Street and traffic signal system improvements include the following projects.

Left Turn Lanes and Signal Phasing

Los Angeles is installing separate left turn lanes, signal phases, and red left turn arrows at five crossings where Long Beach Avenue runs parallel with the MBL and Southern Pacific tracks. These improvements are being installed running southbound only on the west side of the tracks and northbound only on the east side of the tracks. Separate left turn lanes will provide motorists with a place to wait when making left turns across the tracks.

Medians

Raised medians or center line curbs are very effective in restricting motorists from driving around lowered crossing gates. Several grade crossings on the cab signal route segment have raised medians on one or both approaches to the crossing. However, streets running parallel to the tracks or other geometric design features do not allow the construction of medians on one or both approaches. As part of this program, raised concrete medians, centerline curbs, or plastic delineators are being constructed on one or both approaches at seven MBL grade crossings where medians can be placed without disrupting traffic on streets running parallel to the tracks.

Programmed Visibility Heads

At 16 intersections on Long Beach Boulevard where MBL trains are street running, the overhead traffic signal heads for left turns and through traffic are close together and can be confusing for motorists making left turns. At these locations, the through and left turn signal heads will be replaced with programmed visibility heads so that motorists turning left will be able to view the left turn signal but not the through signal.

Illuminated Train Coming Signs

Improved signage to warn drivers that trains are approaching may be effective in reducing the number of train-vehicle collisions, especially on street running route segments or at grade crossings at which left turns across the tracks are possible and no traffic signals are installed.

Illuminated yellow train symbols or Train Coming or Train (Figure 6) signs will be installed at two grade crossings, on Washington Boulevard in Los Angeles. A focus group will be conducted to determine which sign conveys the message that a train is present.

Four-Quadrant Crossing Gates

There are diverse opinions concerning the use of four-quadrant gates at grade crossings. Many rail professionals are concerned that the gates may trap motorists on the tracks and, if the gates fail in a lowered position, block emergency vehicles from passing and create unacceptable traffic jams. Conversely, there are at least three design-related factors typical of many MBL grade crossings that make it appropriate to consider the use of four-quadrant gates. Several grade crossings require vehicles to cross three or four

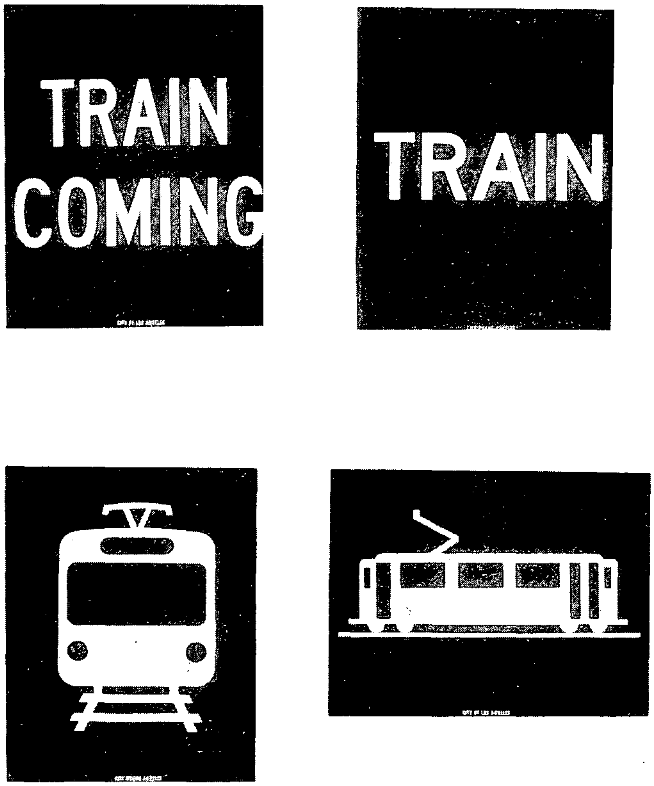


FIGURE 6 Illuminated train warning signs.

tracks. The width of these crossings makes it easier for vehicles to drive around lowered crossing gates, making an S movement.

In addition, vehicles are able to make left turns from streets running parallel to the tracks at many MBL grade crossings. Drivers can turn easily around lowered crossing gates when trying to avoid being delayed by a train.

Many of the accidents on the cab signal route segment have involved a vehicle driving around lowered gates to avoid waiting for a slow-moving freight train or after a train passes through the crossing. The vehicle is then hit by another train that was not seen by the driver. Typically in this situation, the crossing gates are down for a longer time than usual (or the driver, seeing a slow freight train approaching, anticipates that the gates will be down for a longer time).

Demonstration Project Objectives

A highway-rail grade crossing may be considered to have four quadrants, formed by the rail tracks (running from left to right) and the street or highway crossing the tracks (running from top to bottom). With a four-quadrant gate system, a crossing is completely closed off when trains are approaching by gates on both entrances (the typical crossing gate configuration) and by gates on both exits from the crossing.

The use of this type of crossing gate system offers an approach for eliminating or minimizing grade crossing accidents without the high costs and impacts of grade separating. For the MBL, it offers the potential for eliminating collisions involving motorists turning left from streets running parallel to the tracks. Additionally, this system can potentially decrease the number of collisions involving motorists driving around closed crossing gates from the crossing street.

The objectives of the demonstration project are to

- Design and install a four-quadrant gate system which eliminates the risk of motorists being trapped between closed entrance and exit crossing gates;
- Investigate the use of new technologies, collectively referred to as IVHS and becoming more widely used for a variety of street and highway traffic improvement applications, for improving highway-railroad grade crossing safety;
- Evaluate the effectiveness of a four-quadrant gate system in preventing accidents caused by drivers going around closed crossing gates in an urban area LRT operating environment; and
- Determine the additional costs of constructing and maintaining a four-quadrant gate system.

Existing North American Four-Quadrant Gate Installations

Four-quadrant gate systems are currently operational in the United States and Canada at three locations:

- Broad Street in Red Bank, New Jersey, as part of New Jersey Transit;
- 24th Street in Cheyenne, Wyoming, as part of the Burlington Northern; and
- 20th Avenue in Calgary, Alberta, as part of Calgary Transit.

Planned installations include

- Gillette, Wyoming, on the Burlington Northern;
- Charlotte, North Carolina, on the Norfolk Southern; and
- The proposed high speed rail corridors that are part of the Section 1010 of the Intermodal Surface Transportation Efficiency Act of 1991. For example, the Florida Department of Transportation has identified 7 out of 73 crossings on the 67-mi Miami–to–West Palm Beach corridor for the installation of four-quadrant gates.

Design Approach and Assumptions

Three safety features, involving different approaches for preventing vehicles from being trapped between the lowered entrance and exit gates, have been considered as elements of the basis for design for the four-quadrant crossing gate system. They are as follows:

- *Delay in lowering exit gates.* The exit gates will be lowered a number of seconds after the entrance gates are down (or have started down). The exit gates at the Broad Street, New Jersey, crossing where four-quadrant gates are used are delayed by 8 to 10 sec after the entrance gates are lowered. At the 24th Street crossing in Cheyenne, the exit gates are delayed by 2 to 4 sec after the entrance gates are lowered. In proposed guidelines issued in November 1992, FRA suggested that exit gates start down from

1 to 3 sec after the entrance gates start down, providing only a short delay time in the lowering of the exit gates.

- *Vehicle detection system.* The exit gates will not be lowered if a vehicle is detected in the track area. A vehicle detection system, using inductive loops to detect the presence of vehicles, will be interfaced with the exit gate control circuits so that the exit gates are not lowered when a vehicle is detected in the track area (Figure 7). Four-quadrant gates installed at crossings on the Swedish National Railway System are reported to use inductive loop vehicle detectors in this manner.
- *Exit gates fail-safe in "up" position.* The exit gates will be counterbalanced so that they are fail-safe in the "up" position. The gates will need to be driven down and then held down using a "holder clear" type device or other means.

MTA will proceed with a four-quadrant gate demonstration at one crossing on the MBL.

Pedestrian Gates

In the first 3 years of the MBL operations, there have been 25 reported accidents involving MBL trains and pedestrians. Nineteen of the 25 accidents occurred in the cab signal section where the MBL and Southern Pacific share operations, and the LRV operates at speeds up to 55 mph. Most of the accidents occurred at station locations, but most of the fatalities occurred at grade crossings not adjacent to stations. In most locations pedestrians crossings are controlled by flashing lights and bells.

Many of the train-pedestrian accidents appeared to involve pedestrian inattention. In all cases the warning devices (flashers, gates, bells) at the accident locations were operational at the time of the accidents. Whether pedestrians heard or saw the warning devices is not known; however, some of the accidents involved pedestrians in a hurry to catch a train or bus and the pedestrian trying to beat the train.

A recently completed MBL Pedestrian Safety Study provided several general recommendations for treating pedestrian light rail safety issues.

- A barrier should be installed at the end of all walkways leading to/from platforms to delineate the crosswalk edge from vehicle lanes; raised plastic delineation should be installed at the ends of all medians or curbs that are adjacent to MBL tracks.
- Left turn vehicle tracking should be installed at intersection locations to delineate the vehicle left turn path so pedestrians avoid this area.
- All pedestrian crossings of light rail tracks should have primary warning signs installed.
- The crosswalk edge that separates the vehicle lanes from the crosswalks should have curbing installed, between track areas, along the entire length of the track crossings where vehicles are not allowed.

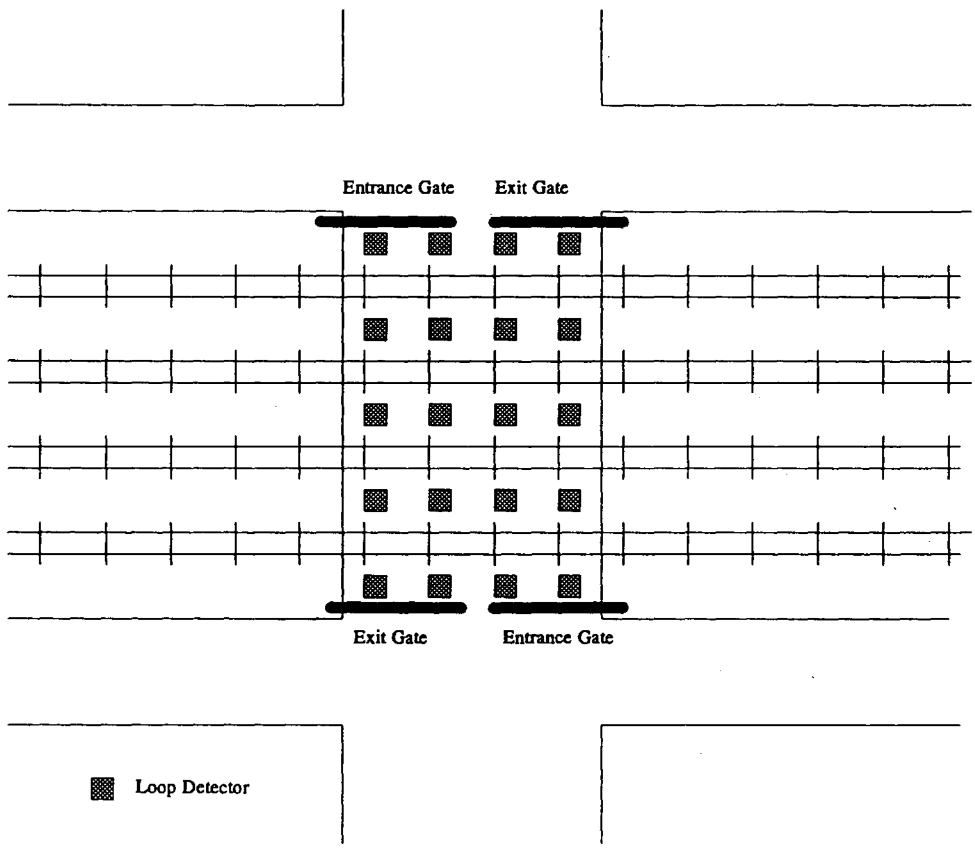


FIGURE 7 Installation of loop detectors at crossing equipped with four-quadrant crossing gates.

- Traffic signal sequences at those locations controlled by crossing gates should be standard along entire line.
- Pedestrian crosswalks crossing tracks in all locations should have standard white crosswalk lines.
- All pedestrian crossing surfaces should be different from street surfaces.

Part of the MBL Safety Program involves the demonstration of pedestrian gates at stations and at one or more pedestrian crossing areas. Three types of barriers are under consideration: railroad-style pedestrian gate areas, Calgary swing gates, and Z-gate channeling.

Criteria used to select pedestrian barrier demonstration installations include

- Number of pedestrian accidents,
- Accident types that can be mitigated with pedestrian barriers,
- Physical characteristics of crossing areas,
- Pedestrian inattention,
- Train speed,
- Second train approaching, and
- Level of pedestrian activity.

Train Operator–Actuated Wayside Horn System

MBL train operators are required to sound the train horn when approaching grade crossings. For grade crossings on the cab signal route segment, the horns are sounded 6 to 8 sec before trains enter the crossings.

In accordance with CPUC General Order 143-A, train horns are required to provide an audible warning of at least 85 dBA at a distance of 100 ft from the train. Although intended to warn motorists and pedestrians at grade crossings, the train horns can be loud and disruptive for persons living and working adjacent to the MBL tracks. For the MBL as well as other rail projects in Southern California, wayside horns may provide an effective means of mitigating certain noise impacts resulting from train operations.

An MBL wayside horn demonstration project is under way. The train horn will be mounted on a pole at two adjacent crossings. When the operator actuates the horn by pushing the button in the train cab, the horn will sound at the crossing. Microwave technology is being used to transmit and receive appropriate radio frequencies. If the wayside horn fails and is not operational, the on-train horn will sound. In addition, the train operator will be able to actuate the on-train horn for trespassers as needed. Noise measurements and community surveys will be made to evaluate the effectiveness of the wayside horn project.

LEGISLATION

MTA successfully sponsored the Rail Transit Safety Act, which seeks to decrease the number of rail-related accidents by imposing additional fines and points on persons who violate rail grade crossing safety laws. The act gives county transportation authorities, local governments, and law enforcement agencies the tools needed to implement expanded enforcement and public education efforts targeted at rail grade crossing safety.

Specifically, the Rail Transit Safety Act provides for the following.

- *Additional fine for grade crossing violations.* Currently, depending on the jurisdiction, the fine for not stopping at a grade crossing when the warning signals are flashing or for driving around a closed gate is $104, whereas the fine for a high-occupancy vehicle lane violation, where the violation does not threaten the life of the driver or of others, is $271. The Rail Transit Safety Act authorizes the court to levy an additional $100 fine for a first violation of a rail grade crossing safety law. If a person is convicted of a second or subsequent offense, the court may order an additional fine of $200.
- *Traffic school for grade crossing violations.* A person convicted of a grade crossing violation may be ordered to attend traffic school and view a film on rail transit safety.
- *Section on crossing safety in DMV driver handbooks.* The act requires DMV to include language regarding rail transit safety. The DMV handbook has recently included information on rail transit. However, additional information on rail transit needs to be added.

EDUCATION

Public education is a critical part of a successful grade crossing safety program. MTA has an ongoing educational program for adults and children along the MBL.

About half of the MBL accidents and fatalities have involved persons with Hispanic surnames; therefore, several safety campaigns are being developed to address the Hispanic audience. MTA is developing a rail transit safety video in Spanish and English that will feature Spanish celebrity figures. In addition, MTA is participating in a Southern California Superman campaign that includes Southern California commuter and freight railroads as well as light and heavy rail transit systems. The theme of the campaign is "Superman is more powerful than a locomotive ... you're not!" The Superman campaign will involve 7 to 8 months of media exposure including television commercials, public service announcements, brochures, and print advertising.

Representative educational programs include

- Operation Lifesaver safety programs;
- School safety programs such as Travis the Owl;
- Public tours to expose the public to rail safety;
- Safety placemat game, promoting rail safety in local fast food restaurants;
- Community outreach programs;
- Handout of rail grade crossing pamphlets and handbills to motorists at MBL crossings;
- Handbills and posters placed in businesses along the MBL;
- Church safety bulletins placed in weekly church bulletins; and
- Ongoing meetings with businesses along the rail line.

CONCLUSIONS

The objective of the MBL Grade Crossing Safety Program is to evaluate various means to discourage or prevent illegal movements being made by vehicles and pedestrians at grade crossings. Methods being evaluated include enforcement, engineering improvements, education, and legislation. Many of the techniques are proving to be successful in achieving the safety program objective.

Enforcement by the LACoSD Traffic Services Detail has proven to be very instrumental in apprehending motorists and pedestrians who violate grade crossings. The 90-day enforcement program produced 7,760 citations. Continuing grade crossing enforcement, using a smaller number of deputies, produces approximately 800 citations per month.

The photo enforcement demonstration project in Compton at two gated crossings resulted in an 84 percent reduction in violations. Violations went from a violation every 1 hr to a violation every 12 hr. During the 7-month demonstration project, 364 citations were issued to motorists.

During this period of intense enforcement, the accident rate in the cab signal area (gated crossings) went from 7 to 2 per year.

Engineering improvements are under way to construct medians at gated crossings, to add protected left turn lanes and signal phasing for streets parallel to the tracks, and to demonstrate four-quadrant and pedestrian gates. These engineering improvements are aimed at eliminating S-turns around down crossing gates and pedestrian inattention near the tracks.

MTA successfully sponsored the Rail Transit Safety Act, a statewide bill that imposes additional fines and points on persons who violate rail grade crossing safety laws. The act also allows a judge to order a grade crossing violator to attend traffic school and view and film on rail transit safety. In addition, it requires the DMV to include more information on rail transit safety.

REFERENCES

1. FTA. Notice of Proposed Rulemaking. *Federal Register*, 49 C.F.R. Part 659, Dec. 9, 1993.
2. *Manual on Uniform Traffic Control Devices.* FHWA, U.S. Department of Transportation, 1978.

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