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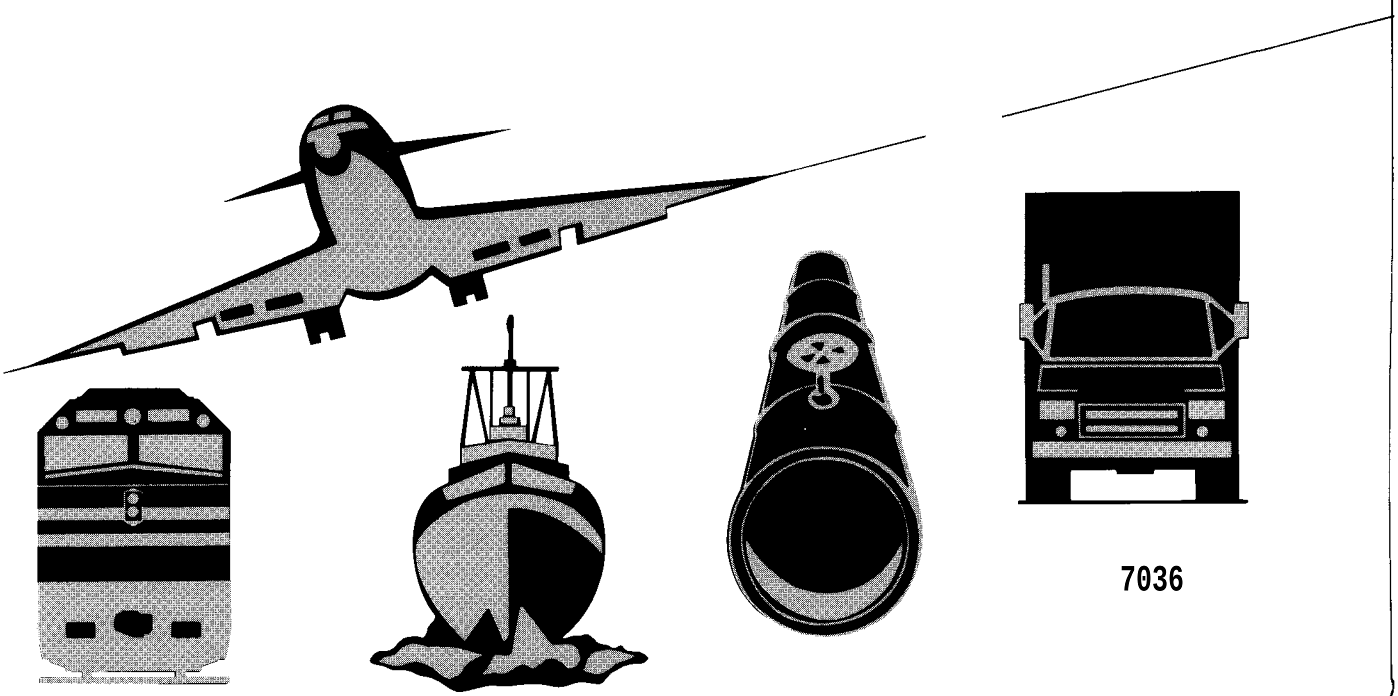
NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

SAFETY STUDY

Safety at Passive Grade Crossings
Volume 1: Analysis



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More than 4,000 accidents occurred at the Nation's active and passive grade crossings in 1996; 54 percent of the accidents and 60 percent of the fatalities were at passive grade crossings, where drivers are not provided warning from train-activated devices. The Safety Board conducted this study to identify some common causes for accidents at passive crossings and to identify remedies to improve safety at passive crossings that are not scheduled for closure or upgrade. The sample of 60 accidents investigated by the Board as part of the study is not intended to be statistically representative of the entire population of accidents at passive grade crossings during the study period, but rather to illustrate a range of passive grade crossing accidents. The report also relates information obtained at the Board's 1997 public forum on passive crossing safety. The safety issues include (a) the adequacy of existing warning systems to alert the driver to the presence of a passive crossing and an oncoming train; (b) roadway and track conditions that affect a driver's ability to detect the presence of an oncoming train; (c) behavioral factors that affect a driver's ability to detect the presence of an oncoming train; (d) the adequacy of existing driver education material regarding the dangers of passive grade crossings and driver actions required; (e) the need for a systematic and uniform approach to passive grade crossing safety; (f) and the need for improved signage at private passive crossings. Safety recommendations concerning these issues were made to the U.S. Department of Transportation; the Federal Highway Administration; the National Highway Traffic Safety Administration; the Federal Railroad Administration; the States; Operation Lifesaver, Inc.; the American Association of Motor Vehicle Administrators; the American Automobile Association; the American Association of State Highway and Transportation Officials; the Professional Truck Drivers Institute of America; the Advertising Council, Inc.; the Association of American Railroads; the American Short Line and Regional Railroad Association; and the American Public Transit Association.

The National Transportation Safety Board is an independent Federal agency dedicated to promoting aviation, railroad, highway, marine, pipeline, and hazardous materials safety. Established in 1967, the agency is mandated by Congress through the Independent Safety Board Act of 1974 to investigate transportation accidents, determine the probable causes of the accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies involved in transportation. The Safety Board makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews.

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Safety Study

Safety at Passive Grade Crossings
Volume 1: Analysis

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Conversion Factors for International Standard (SI) Units

To convert from	*to*	*multiply by*
feet	meters	0.3048
miles	kilometers	1.6093
kilometers	miles	0.6214
degrees Fahrenheit (°F)	degrees Celsius (°C)	5/9 (°F minus 32)

Acronyms and Abridged Terms Used in the Report

AAA	American Automobile Association
AAMVA	American Association of Motor Vehicle Administrators
AAR	Association of American Railroads
AASHTO	American Association of State Highway and Transportation Officials
AASHTO Greenbook	*A Policy on Geometric Design of Highways and Streets* published by the AASHTO
Action Plan	1994 DOT Action Plan developed by the FHWA, FRA, FTA, and NHTSA
ADT	average daily traffic
AREA	American Railway Engineering Association (now the American Railway Engineering and Maintenance of Way Association)
CAS	casualty file in the Railroad Accident/Incident Reporting System of the FRA
CFR	Code of Federal Regulations
CSX	CSX Corporation
DOT	U.S. Department of Transportation
FHWA	Federal Highway Administration
FR	Federal Register
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
GAO	General Accounting Office
GCIR	grade crossing accident/incident file in the Railroad Accident/Incident Reporting System of the FRA
GCIS	Grade Crossing Inventory System of the FRA
Handbook	*Railroad–Highway Grade Crossing Handbook* published by the FHWA
ICC	Interstate Commerce Commission (now the Surface Transportation Board)
ID	identification
IDEA	Innovations Deserving Exploratory Analysis program of the Transportation Research Board
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITS	intelligent transportation systems
ITS America	Intelligent Transportation Society of America
IVSAWS	in-vehicle safety advisory and warning systems
MUTCD	*Manual on Uniform Traffic Control Devices* published by the FHWA
NHTSA	National Highway Traffic Safety Administration
NPRM	notice of proposed rulemaking
NTSB	National Transportation Safety Board
OL	Operation Lifesaver, Inc.
PTDIA	Professional Truck Drivers Institute of America
RAIR	rail equipment accident/incident file in the Railroad Accident/Incident Reporting System of the FRA
U.S.C.	United States Code
Volpe Center	John A. Volpe National Transportation Systems Center
VPAS	vehicle proximity alerting systems
VTRC	Virginia Transportation Research Council

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Executive Summary

More than 4,000 accidents have occurred at the Nation's active and passive grade crossings each year from 1991 through 1996. Many of the accidents at active crossings have involved highway vehicle drivers who did not comply with train-activated warning devices installed at the crossings. This failure to comply often includes driver actions resulting from a deliberate decision, such as driving around a lowered crossing gate arm or ignoring flashing lights. Drivers at passive crossings are not provided warnings from train-activated devices; consequently, they must rely on a system of grade crossing signs and pavement markings, passive devices, that are designed to warn drivers only of the presence of a crossing. No element of this passive system changes to alert drivers to an oncoming train. Further, the effectiveness of the passive system is influenced by characteristics of the physical layout of the crossing, such as an adequate view of the area surrounding the crossing (sight distance) and roadway alignment, that affect the information given to an approaching motorist regarding an upcoming hazard.

According to the Federal Railroad Administration, there were 4,054 accidents in 1996 that involved highway vehicles at grade crossings; 54 percent (2,208) of those accidents occurred at passive grade crossings. About 60 percent of the fatalities from all grade crossing accidents in 1996 (247 of 415 fatalities) were at passive grade crossings.

The cost to eliminate or upgrade passive grade crossings is very high. According to the General Accounting Office, the average cost of adding lights and gates in 1995 was $150,000 per grade crossing. The total cost to upgrade the 96,759 passive crossings on public roadways would be about $14 billion. Gates and lights do not completely eliminate the hazards present at crossings, and, therefore, sole reliance on them would reduce but not eliminate all the fatalities. The ultimate solution from a safety standpoint would be a standard grade separation, which usually involves construction of bridges or overpasses and costs an estimated $3 million per crossing. The large number of passive grade crossings, the high percentage of fatalities that occur at passive grade crossings, and the cost to eliminate or upgrade passive grade crossings prompted the Safety Board to conduct this study to identify some of the common causes for accidents at passive grade crossings, and to identify less costly remedies to improve safety at passive crossings not scheduled for closure or upgrade.

For this study, the Safety Board investigated 60 grade crossing accidents that occurred between December 1995 and August 1996. The Safety Board selected for study accidents involving a collision between a train and a highway vehicle occurring at a passive grade crossing, wherein the highway vehicle was sufficiently damaged to require towing. The sample of accidents is not intended to be statistically representative of the entire population of accidents at passive grade crossings during the study period, but rather to illustrate a range of passive grade crossing accidents. A probable cause was determined for each accident in the study. Overall, driver error was cited as the primary cause in 49 of the 60 accident cases: driver disregard for the stop sign in 13 cases, and the driver's failure to look for a train in 16 cases. In 7 of the remaining 11 cases, the probable cause was determined to be related to roadway conditions that affected the driver's ability to detect the presence of a passive crossing or an oncoming train; roadway and track conditions were cited as the probable cause in 3 of the 11 cases.

In May 1997, the Safety Board convened a 2-day public forum in Jacksonville, Florida, to gather information about issues affecting safety at passive grade crossings. Witnesses included experts from the railroad industry; law enforcement; research groups; Operation Lifesaver; and Federal, State, and local government agencies. Those involved in grade crossing accidents, both highway vehicle occupants and traincrews, testified about their personal experiences. In addition, representatives from Canada and Italy discussed passive grade crossing issues and experiences in their countries.

Based on the results of the Safety Board's accident investigations and the information gathered at the public forum, the safety issues discussed in the report include the following:

- the adequacy of existing warning systems to alert the driver to the presence of a passive crossing and an oncoming train;
- roadway and track conditions that affect a driver's ability to detect the presence of an oncoming train;
- behavioral factors that affect a driver's ability to detect the presence of an oncoming train;
- the adequacy of existing driver education material regarding the dangers of passive grade crossings and driver actions required;
- the need for a systematic and uniform approach to passive grade crossing safety; and
- the need for improved signage at private passive crossings.

The issue of safety at passive grade crossings is complex; therefore, Volume 1 (NTSB/SS-98/02) of the report first discusses the problems drivers encounter at passive crossings, then presents the Board's analysis, conclusions, and recommendations. Volume 2 (NTSB/SS-98/03) of the report contains case summaries of the 60 accidents investigated by the Safety Board for this study.

As a result of this study, safety recommendations were issued to the U.S. Department of Transportation; the Federal Highway Administration; the National Highway Traffic Safety Administration; the Federal Railroad Administration; the States; Operation Lifesaver, Inc.; the American Association of Motor Vehicle Administrators; the American Automobile Association; the American Association of State Highway and Transportation Officials; the Professional Truck Drivers Institute of America; the Advertising Council, Inc.; the Association of American Railroads; the American Short Line and Regional Railroad Association; and the American Public Transit Association.

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Chapter 1

Introduction

In the afternoon of March 9, 1997, a Ford Aerostar passenger van was traveling eastbound on Kirkwood Road in Shelby County, Ohio.[1] The family in the van resided in Vandalia, Ohio, about 40 miles away; it is not known whether the driver was familiar with the road. Light rain was falling, and the temperature was 54 °F. Shortly after 3 p.m., the van approached a passive grade crossing,[2] which was equipped with a circular railroad advance warning sign and a standard crossbuck sign. The required railroad crossing pavement markings consisting of an “X,” the letters “RR,” a “no passing” mark, and “certain transverse lines”[3] [to delineate the beginning and end of the pavement markings] were not present on the two-lane asphalt road on either the eastbound or the westbound approaches to the grade crossing.

Houses built along Kirkwood Road obstruct an eastbound motorist’s view of a southbound train until the motor vehicle is within 118 feet of the crossing, at which point the approaching train would be visible if it were within 207 feet of the crossing. The obstructed view is referred to as “limited sight distance.”[4] A motorist traveling at the unposted speed limit of 55 miles per hour (mph) would not have had sufficient time to react to the presence of the train and to stop the vehicle prior to the crossing. One witness estimated that the van was traveling at about 25–30 mph. At 25 mph, a motorist would still require more than 160 feet of sight distance along the highway in order to see the approaching train, then react and stop the vehicle in time to avoid an accident.

According to the traincrew, the van driver slowed, looked toward the train, and accelerated into the crossing; the van was struck by a southbound CSX Corporation (CSX) freight train. Data from the locomotive event recorder indicated that the train’s horn was sounding; the traincrew reported that the locomotive headlight and auxiliary

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[1] National Transportation Safety Board (NTSB) accident No. NRH-97-FHX-08. The accident occurred after the sampling period for this safety study and is not one of the accident cases in the Safety Board’s analysis. The accident is described here to illustrate some of the problems at passive grade crossings.

[2] Passive grade crossings have only traffic control devices such as the crossbuck, stop signs, or pavement markings that do not change to give the highway vehicle driver active visual or auditory warning of an approaching train. Active warning devices such as flashing lights, bells, or gates are triggered by the approach of a train along the tracks, providing advance warning to the oncoming motorist that a train is approaching the crossing. Distinctions between active and passive crossings are discussed in more detail in the following chapters.

[3] U.S. Department of Transportation, Federal Highway Administration. 1988. Manual on uniform traffic control devices. Washington, DC. Variously paged. (Section 8B-4.)

[4] Sight distance is discussed in detail in later chapters of this report.

alerting lights were illuminated. The van overturned and came to rest 87 feet east of the crossing. The driver, his wife, and their three children were killed; the traincrew were not injured.

About 1:30 p.m. on August 23, 1996, a 1978 Ford Courier pickup truck was traveling along an earthen road west of Naponee, in Franklin County, Nebraska (study case 62). The weather was clear, and the temperature about 90 °F. The speed limit on the road was 25 mph. The roadway runs nearly parallel with railroad tracks until about 1 mile west of Naponee, where it makes a sharp left turn to intersect the tracks at an angle of 135°. Trees and brush limited the sight distance to within 15 feet of the grade crossing, which was equipped, as required, with a circular railroad advance warning sign and a standard crossbuck sign. According to the traincrew, the train's headlight was illuminated, and the engineer sounded the horn prior to entering the crossing. The pickup truckdriver, a former county supervisor for Franklin County, entered the grade crossing and was struck by a Burlington Northern Santa Fe local freight train. The driver of the pickup was killed; the traincrew were not injured.

The above accidents are examples of the more than 4,000 accidents that have occurred at the Nation's active and passive grade crossings each year from 1991 through 1996.[5] Many of the accidents at active crossings have involved highway vehicle drivers who did not comply with train-activated warning devices installed at the crossings. This failure to comply often includes driver actions resulting from a deliberate decision, such as driving around a lowered crossing gate arm or ignoring flashing lights. Because passive crossings do not have train-activated devices at the crossings, drivers must rely on a system of grade crossing signs and pavement markings, passive devices, that are designed to warn drivers of the presence of a crossing. No element of this passive system changes to alert drivers to an oncoming train.[6] Further, the effectiveness of the passive system is influenced by characteristics of the physical layout of the crossing, such as an adequate view of the area surrounding the crossing (sight distance) and roadway alignment, that affect the information given to an approaching motorist regarding an upcoming hazard.

[5] Not all data are available for 1997.

[6] Motorists at passive grade crossings must be able to see an oncoming train. Crossing characteristics that affect the motorist's ability to see a train are discussed in chapter 4 of this report. Motorists can also be alerted to a train by the train horn, which traincrews are required to sound near active and passive grade crossings, and by auxiliary locomotive alerting lights, which are sometimes activated as a train approaches certain crossings. The effectiveness of the train horn and use of auxiliary locomotive lights to alert motorists to an oncoming train are discussed in chapter 5 of this report.

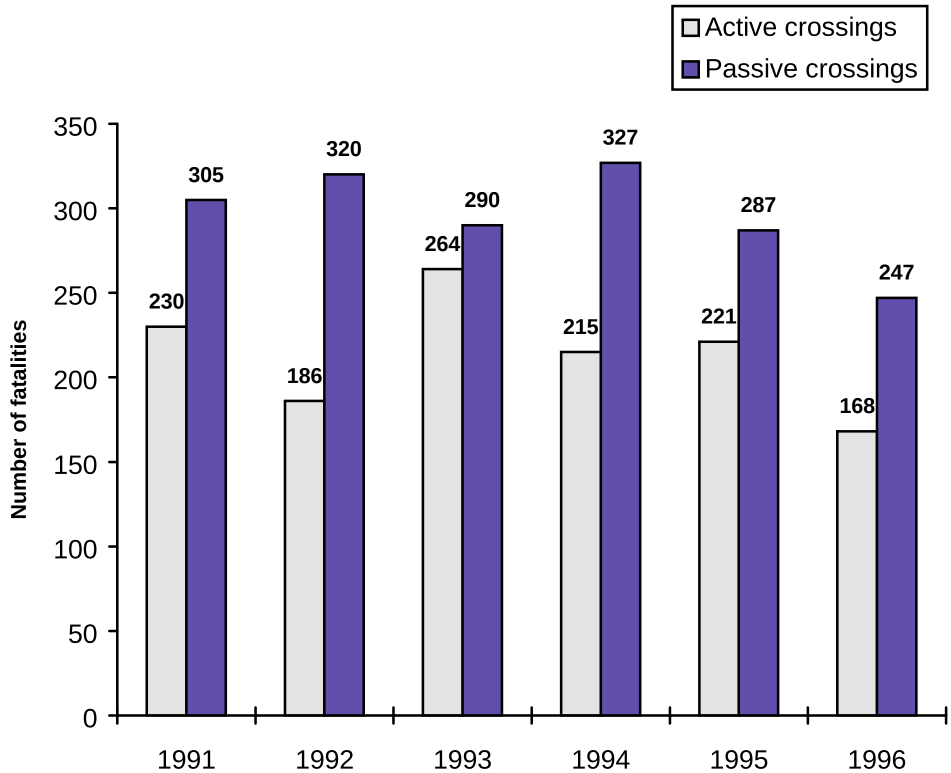

Figure 1–1. Fatalities from accidents involving highway vehicles at active and passive highway–rail grade crossings, 1991–1996. (Source: U.S. Department of Transportation, Federal Railroad Administration. 1992–1997. Highway–rail crossing accident/incident and inventory bulletin. Nos. 14–19. Washington, DC. Annual.)

In 1996, the States and railroads reported to the Federal Railroad Administration (FRA) that there were 265,721 grade crossings; 75 percent, or 198,985, were passive crossings. According to the FRA, there were 4,054 accidents in 1996 that involved highway vehicles at grade crossings;[7] 54 percent (2,208) of those accidents occurred at passive grade crossings. About 60 percent of the fatalities from all grade crossing accidents in 1996 (247 of 415 fatalities) were at passive grade crossings. Figure 1–1 shows the number of fatalities from accidents involving highway vehicles at active and passive crossings for the 1991–1996 period.

[7] The annual statistics in this report are based on information reported to the Department of Transportation's FRA. They do not include statistics from organizations not subject to FRA authority. Those organizations file safety reports with the Federal Transit Administration (FTA).

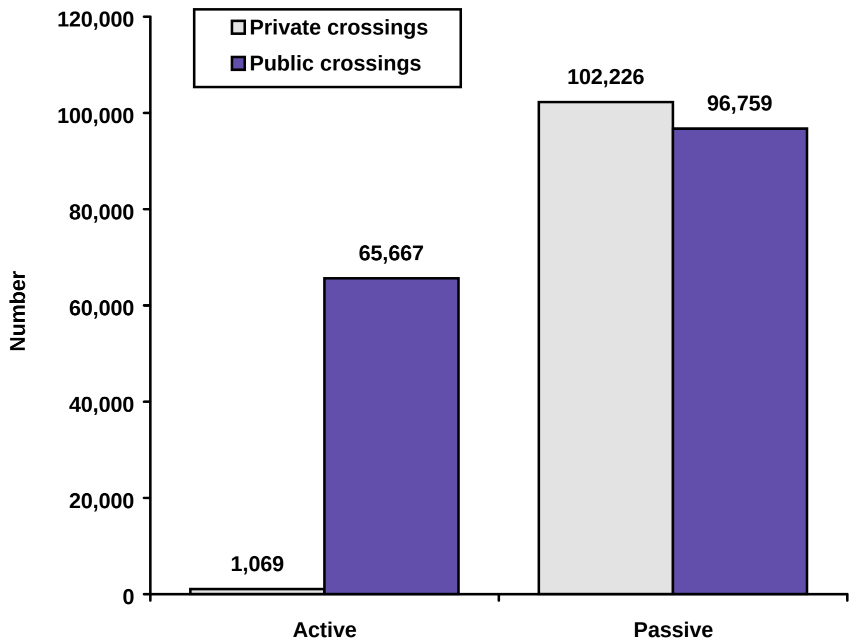

Figure 1–2. Number of active and passive, public and private grade crossings in the United States, 1996. (Source: U. S. Department of Transportation, Federal Railroad Administration. 1997. Highway–rail crossing accident/incident and inventory bulletin. No. 19. Washington, DC.)

Grade crossings are also categorized as either public or private. A private crossing is a grade crossing that is not classified by the FRA as a public crossing,[8] such as a crossing on a private road giving access to a farm. Of the 103,295 private crossings reported to the FRA, only 1,069 have active signals, thus 99 percent of all private grade crossings are also passive crossings (figure 1–2).

One of the primary distinctions between active and passive crossings is the amount of traffic, both on the highways and on the railroad tracks, that utilizes them. According to data from the FRA, the highway average daily traffic (ADT) at public active crossings is 4,003 vehicles, and at public passive crossings the corresponding average ADT is 849 vehicles.[9] The average reported daily train traffic is also higher at public active crossings (13.7 trains) than it is at public passive crossings (6.2 trains). Although the train and highway traffic is lower at passive crossings, these crossings still pose a risk.

[8] A crossing is classified as public if “(a) the roadway is a part of the general system of public streets and highways, and (b) under the jurisdiction of and maintained by a public authority, and (c) open to the general traveling public.” (U.S. Department of Transportation, Federal Railroad Administration, Office of Safety. 1996. Highway-rail crossing inventory instructions and procedures manual. Washington, DC. Variously paged (page 1-6).)

[9] Information on highway and train traffic at private crossings is not available.

In an effort to reduce the number of fatalities at grade crossings, the FRA Administrator announced an initiative in 1991 intended to eliminate 25 percent of all grade crossings by the year 2001.[10] Despite active involvement by the railroads, States, and the Federal government, however, the effort to eliminate crossings is progressing very slowly. According to data from the FRA, the number of passive crossings, both public and private, has been decreasing about 2 percent per year since 1992, a statistic that includes both the closure of crossings and the upgrade of some passive crossings to active by the installation of active warning devices. The number of all crossings (active and passive) decreased 9.3 percent between 1990 and 1996.[11]

The cost to eliminate or upgrade passive grade crossings is very high. According to the General Accounting Office (GAO),[12] the average cost of adding lights and gates in 1995 was $150,000 per grade crossing. The total cost to upgrade the 96,759 passive crossings on public roadways would be about $14 billion. Gates and flashing lights do not completely eliminate the hazards present at crossings,[13] and, therefore, sole reliance on them would reduce but not eliminate all the fatalities. The ultimate solution from a safety standpoint would be a standard grade separation, which usually involves construction of bridges or overpasses and costs an estimated $3 million per crossing.[14]

The costs of a grade crossing accident, however, are also high. In 1994, a single fatality cost society more than $830,000, and the average cost for each critically injured survivor was $706,000.[15] A single accident involving a passenger train, for example, could easily result in costs to society of several million dollars. In addition, the railroads and roadway users involved in accidents at grade crossings also incur direct costs from property damage and loss of the use of equipment.

[10] Carmichael, Gilbert E. 1991. Highway-rail grade crossings: the unfinished safety agenda. In: The job's not done: Proceedings, 1991 national conference on highway-rail safety; 1991 July 7-10; Philadelphia, PA. College Station, TX: TransCom: 5-9.

[11] Safety Board staff conversation with the Staff Director of Federal Railroad Administration, Office of Safety, Highway Rail Crossing and Trespasser Division, at a technical review meeting for a draft of this report, May 21, 1998.

[12] United States General Accounting Office. 1995. Railroad safety: status of efforts to improve railroad crossing safety. GAO/RCED-95-191. Washington, DC. 58 p. (page 33.)

[13] Erlich, Pat. 1989. Identifying improvement options. In: Rail-highway safety: today and tomorrow: Proceedings, 1989 national conference on rail-highway safety; 1989 July 9-12; San Diego, CA. College Station, TX: TransCom: 45-52.

[14] GAO (1995, page 33).

[15] National Highway Traffic Safety Administration. [n.d.] The economic cost of motor vehicle crashes, 1994. NHTSA Technical Report. Washington, DC. (Report accessed on July 3, 1997, on the NHTSA Web site: http://www.nhtsa.dot.gov/people/economic/ecomvc1994.html.)

The large number of passive grade crossings, the high percentage of fatalities that occur at passive grade crossings, and the cost to eliminate or upgrade passive grade crossings prompted the Safety Board to conduct this study to identify some of the common causes for accidents at passive grade crossings, and to identify less costly remedies to improve safety at passive crossings not scheduled for closure or upgrade.

Chapter 2 contains background on Federal and State regulatory responsibilities regarding grade crossings, including initiatives to address grade crossing safety, and on previous Safety Board activity related to safety at grade crossings. Chapter 3 contains a description of the study methods used by the Safety Board, as well as an overview of the accident sample. A description of the accident crossings, including the presence and condition of the signs and warning devices used at passive crossings, is included in chapter 4. Chapter 4 also discusses the physical characteristics at the accident crossings that affect a driver's ability to see an oncoming train. Chapter 5 discusses driver awareness of the presence of a crossing and an oncoming train. Chapter 6 presents proposals to improve safety at passive grade crossings. The last sections of the report contain the Safety Board's conclusions and recommendations.

Chapter 2

Background

Grade crossing accidents like those described in the previous chapter are not new to the railroad or highway safety communities. Similar accidents were mentioned in newspaper and magazine articles as early as 1907,[16] and official records maintained by the Interstate Commerce Commission (ICC, now the Surface Transportation Board) in 1917 reported 1,083 grade crossing fatalities involving motor vehicles.[17] The Federal Highway Safety Act of 1973 provided funding to the States specifically for grade crossing improvement projects, and the number of fatalities at grade crossings began to decline. Currently, 415 to 560 grade crossing fatalities occur each year.[18] Appendix A provides the number of grade crossing accidents, fatalities, and persons injured for 1991 through 1996.

Regulatory Responsibility for Grade Crossings

In the 19th century, as the networks of railroad tracks and roads were being constructed, grade crossings were under the jurisdiction of the State or local authority in whose territory they lay. A series of court cases attempted to assess the degrees to which the railroad and the local authorities were responsible for safety at these grade crossings. Along with safety responsibility came monetary responsibility for crossing improvements, and for that reason the issue was intensely and repeatedly debated. Initial decisions in the 19th century generally determined that the owner of a property, in this case the railroad, was responsible for maintaining that property in a condition that did not undermine public safety, and that local authorities were within their rights to mandate specific crossing improvements.[19]

[16] Batting, Charles W. 1907. Our railways' annual slaughter. Van Norden Magazine, January. (page 62).

[17] The number of fatalities remained between 1,000 and 2,200 per year until the mid-1970s.

[18] These numbers represent the range of fatality counts occurring in the years 1991–1996.

[19] U.S. Department of Transportation, Federal Railroad Administration; Federal Highway Administration. 1971. Railroad-highway safety. Part I: A comprehensive statement of the problem. Report to Congress. Washington, DC. 95 p., plus appendixes. (page A-12).

The advent of the motor vehicle changed both the magnitude of the safety problem at grade crossings and the level of Federal involvement in the matter. In the early decades of the 20th century, Federal-aid funds were made available to build a system of rural roads, and in some cases a portion of these funds were available for eliminating hazards at grade crossings.[20] Beginning in 1917 and continuing through the mid-1960s, the ICC maintained records of accidents occurring at grade crossings, but it did not have jurisdictional authority to regulate grade crossing warning or protective devices.[21] In 1935, the courts also determined that, because the primary beneficiaries to safety improvements at grade crossings are the highway users rather than the railroads, the public should bear a proportion of the cost to be determined by fairness and beneficial interest.[22] According to U.S law, for any project paid for by the Federal funds earmarked for grade crossing improvements, the railroads cannot be required to pay more than 10 percent of the project costs.[23] The Secretary of the U.S. Department of Transportation (DOT), empowered by Congress to determine the actual percentage to be paid by the railroads, has set the current maximum at 5 percent of the project costs, and then only under very limited circumstances.[24] On projects not paid for out of the Federal-aid funds, the railroads can pay a higher proportion of the costs.

In late 1966, Congress passed the Department of Transportation Act, wherein the Federal Highway Administration and the Federal Railroad Administration, among other agencies, were created. The authority held by each of these administrations regarding grade crossings is highlighted in the following paragraphs.

The **Federal Highway Administration (FHWA)** regulates aspects of the grade crossing that affect highway safety. FHWA publications provide guidelines and standards for correct design of grade crossings, assessment of safety at a grade crossing, and appropriate placement of traffic control devices at and on the approach to a grade crossing. The FHWA also administers the distribution of funds authorized in Title 23 United States Code (23 U.S.C.) Section 130, which allocates money to the States specifically for the purpose of eliminating hazards at railroad–highway grade crossings.[25]

[20] FRA and FHWA (1971, page A-8).

[21] FRA and FHWA (1971, page A-22).

[22] FRA and FHWA (1971, page A-13).

[23] The railroads' 10-percent responsibility is current law. (23 U.S.C. [United States Code] §130 (b). Highway Safety Act of 1973.)

[24] The railroad, which may voluntarily pay more, is required to pay only 5 percent of the cost of projects that involve the elimination of a grade crossing through grade separation or through railroad or highway relocation. (23 CFR [Code of Federal Regulations] §646.210.)

[25] As previously noted, the Federal Highway Safety Act of 1973 provided this funding. FHWA funds for State use are discussed later in this report.

The **Federal Railroad Administration (FRA)** regulates the aspects of grade crossing safety pertaining specifically to the railroads: track safety, active signals, and train safety and conspicuity. For example, the agency's regulations specify the type of lighting to be placed on a locomotive (49 CFR [Title 49 Code of Federal Regulations] 229.125), the audibility of the train horns (49 CFR 229.129), and the inspection, testing, and maintenance standards for active grade crossing signal system safety (49 CFR 234). The FRA also conducts research on topics affecting safety at grade crossings; this research will be discussed in appropriate sections of this report.

When the FRA was created in 1967, it assumed the recordkeeping responsibilities previously held by the ICC, and it currently requires railroads to report information on accidents/incidents occurring at grade crossings. The information reported by the railroads is contained in the Railroad Accident/Incident Reporting System, which consists of three files: the casualty file (CAS), the rail equipment accident/incident file (RAIR), and the highway–rail grade crossing accident/incident file (GCIR).[26] The FRA also maintains the Grade Crossing Inventory System (GCIS) database, a large file intended to document every grade crossing in the United States. This reporting system is discussed in more detail in chapter 6.

In 1970, Congress directed the Secretary of Transportation to "submit . . . a comprehensive study of the problem of eliminating and protecting railroad grade crossings."[27] The FRA and the FHWA responded with a two-part report: Part I included a statement of the problem and was released in November 1971.[28] Part II contained the recommended solutions[29] and was released in August 1972. Part II stated that

> [t]o assist in a systematic approach to the planning and evaluation of programs for the improvement of railroad–highway crossings, certain information is essential, both for individual crossings and for groups of crossings. This essential information fits into two categories, (1) inventory data and (2) accident statistics, with a third factor, crossing identification, equally essential for correlation of the first two. Both the inventory and the accident statistics information must be obtained on a crossing-by-crossing basis, and be of sufficient detail for planning and program purposes.

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[26] Deaths, injuries, or occupational illnesses arising from railroad operations are reported in CAS. The RAIR contains data on events involving the operation of rail equipment and causing more than a certain threshold dollar amount of damage, and the GCIR file contains data on "any impact, regardless of severity, between a railroad on-track equipment consist and any user of a public or private crossing site." (U.S. Department of Transportation, Federal Railroad Administration, Office of Safety. FRA guide for preparing accidents/incidents reports. DOT/FRA/RRS-22. Washington, DC. Variously paged (page VIII-1).)

[27] U.S. Code Congressional and Administrative News. Laws of 91st Congress, Second Session. Washington, DC. (page 1133).

[28] Federal Railroad Administration; Federal Highway Administration. 1971. Railroad-highway safety. Part I: A comprehensive statement of the problem. Report to Congress. Washington, DC. 95 p., plus appendixes.

[29] Federal Railroad Administration; Federal Highway Administration. 1972. Railroad-highway safety. Part II: Recommendations for resolving the problem. Report to Congress. Washington, DC. 108 p. (page 58).

Congress acted on these recommendations in the Federal Highway Safety Act of 1973, wherein States are enjoined to "conduct and systematically maintain a survey of all highways to identify those railroad crossings which may require separation, relocation, or protective devices," and the Secretary of Transportation is required to provide an annual report to include, among other things, an analysis and evaluation of each State program.[30] The FRA, in order to facilitate the production of the required reports, established the GCIS and accident/incident data files still in use today.[31]

Guidelines

Several organizations and agencies publish guidelines and standards for highway or railroad design and engineering issues that pertain to grade crossings.

A Policy on Geometric Design of Highways and Streets

The American Association of State Highway and Transportation Officials (AASHTO) publishes *A Policy on Geometric Design of Highways and Streets* (hereinafter called the AASHTO Greenbook), which contains guidelines to assist highway engineers in the design of safe roadway systems.[32] These guidelines include specifications for appropriate and safe vertical and horizontal roadway alignment at grade crossings, and also include suggested formulas for calculating the sight distance requirements at grade crossings. The sight distance calculations use some assumptions about the size and stopping distances of the vehicles and operators using the grade crossing: (1) the design vehicle is assumed to be a large truck, because a large truck would require the greatest stopping distance, and its length and slow acceleration capabilities mean that it would occupy the crossing for a relatively long time;[33] (2) the time that the highway driver needs to perceive the danger and react appropriately is assumed to be 2.5 seconds; (3) the speed of the highway vehicle is assumed to be the speed limit on the road; (4) the

[30] U.S. Code Congressional and Administrative News. Laws of 93rd Congress, First Session. Washington, DC. (page 332).

[31] The National Highway Traffic Safety Administration (NHTSA) within the DOT also includes data about grade crossings in its databases. The first of these databases is the Fatality Analysis Reporting System, which contains information about every fatal accident occurring on public roadways. The second database is the General Estimates System, which contains a statistical sample of nonfatal accidents occurring on public roadways.

[32] American Association of State Highway and Transportation Officials. 1990. A policy on geometric design of highways and streets, 1990. Washington, DC. 1044 p.

[33] Assumptions about the design vehicle drew upon information provided in the *Railroad-Highway Grade Crossing Handbook* published by the FHWA and described later in this chapter. According to the Handbook (page 35), "unless trucks are prohibited on the crossing, it is desirable that the design vehicle be at least a tractor semi-trailer truck."

speed of the train is assumed to be the typical maximum train speed reported in the FRA inventory database; and (5) stopping distances calculated assume a coefficient of friction measured on wet road surfaces.

Manual on Uniform Traffic Control Devices

This manual, referred to as the "MUTCD," is published by the FHWA.[34] It provides State and local highway engineers with standards for sign, signal, and pavement marking design, as well as for their appropriate placement. The standards set forth in the MUTCD become State law when States adopt them, and all States are required to either adopt the MUTCD or adopt a State manual that conforms to the MUTCD.[35] All 50 States and the District of Columbia require that all traffic control devices on streets and highways under public agency jurisdiction conform to the specifications in the MUTCD.[36] The next edition of the MUTCD is scheduled to be published in the year 2000.

The language in the MUTCD determines whether a particular traffic control device is mandatory, recommended, or whether it is simply permitted. The language in question is defined as follows:

> 1. SHALL—*mandatory* condition. Where certain requirements in the design or application of the device are described with the "shall" stipulation, it is mandatory when an installation is made that these requirements be met.
>
> 2. SHOULD—an *advisory* condition. Where the word "should" is used, it is considered to be advisable usage, recommended but not mandatory.
>
> 3. MAY—a permissive condition. No requirement for design or application is intended.[37]

For example, the railroad crossing sign, or crossbuck (MUTCD designation R15-1), is mandatory and "**shall** [emphasis added] be used on each roadway approach to every grade crossing, alone or in combination with other traffic control devices."[38] If there are multiple tracks at the crossing, "the number of tracks **shall** [emphasis added] be indicated" by an inverted T-shaped sign (R15-2). Other devices, such as the circular railroad crossing advance warning sign (W10-1) (a yellow circular sign inscribed with a large "X" and the letters "RR") and the railroad crossing pavement markings ("to consist of an X, the letters RR, a no passing marking . . . , and certain transverse lines"[39]), **shall** be placed on both approaches to the crossing, but these may be omitted under certain conditions. In the case

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[34] U.S. Department of Transportation, Federal Highway Administration. 1988. Manual on uniform traffic control devices. Washington, DC. Variously paged.

[35] 23 CFR §655.603.

[36] Jennings, L. Stephen, comp., ed. 1995. Compilation of State laws and regulations affecting highway-rail grade crossings. 2nd ed. Washington, DC: Federal Railroad Administration. Variously paged (page 5-1).

[37] MUTCD (1988, page 1A-4).

[38] MUTCD (1988, page 8B-1).

[39] MUTCD (1988, page 8B-5).

of the “do not stop on tracks” sign and a few other systems, the MUTCD says only that they **should** or they **may** be installed. Appendix B contains a copy of the MUTCD chapter that lists and illustrates the specific grade crossing signs and markings for which design and placement standards are available.

The MUTCD classifies signs according to whether they inform the driver (1) of the need to obey specific regulations (regulatory signs), (2) of the presence of hazards (warning signs), or (3) of highway routes and directions (guide signs). Stop signs, yield signs, and speed limit signs are all examples of regulatory signs, informing drivers of the need to obey certain regulations, and providing them with explicit instructions. The crossbuck and multiple tracks signs, placed at grade crossings, are regulatory signs.[40] Warning signs “require caution on the part of the vehicle operator and may call for reduction of speed or a maneuver in the interest of his own safety.”[41] The yellow diamond-shaped signs, such as those indicating an upcoming “T” intersection, or a “stop ahead,” are warning signs; the circular railroad crossing advance warning sign used at grade crossings is classified as a warning sign.[42] Guide signs, such as the shield-shaped interstate route signs are intended to guide drivers along roadways and to direct them toward cities and other points of interest; none of the signs specific to grade crossings are guide signs.

Railroad–Highway Grade Crossing Handbook

The *Railroad–Highway Grade Crossing Handbook* (hereinafter called the Handbook) is published by the FHWA.[43] It draws on a number of different sources (including the MUTCD and the AASHTO Greenbook) to provide an overview of some of the legal and jurisdictional considerations surrounding grade crossings, a brief discussion of the grade crossing users, design issues involving the physical and geometric characteristics of the crossing, and several formulas by which the risk at a crossing may be assessed. The Handbook also provides guidelines for the identification and selection of active warning devices. Also included are discussions of issues surrounding private grade crossings, shortline railroads, high speed rail corridors, and special vehicles such as trucks carrying hazardous materials. The Handbook was developed to provide a single source for all the guidelines and alternative grade crossing improvements that had proved effective and that had been accepted nationwide.

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[40] MUTCD (1988, page 8A-1).

[41] MUTCD (1988, page 2C-1).

[42] MUTCD (1988, page 8B-3).

[43] U.S. Department of Transportation, Federal Highway Administration. 1986. Railroad-highway grade crossing handbook. 2nd ed. FHWA-TS-86-215. Washington, DC. 261 p.

Manual for Railway Engineering

This manual, published by the American Railway Engineering Association (AREA, now the American Railway Engineering and Maintenance of Way Association), contains information and specifications for the engineering and design of railway roadway, track, and structures, including grade crossings.[44] Among the grade crossing topics covered in this manual are discussions of crossing surface materials, crossing profile, and traffic control devices needed at crossings. The AREA manual is used by railroads and consultants as guidelines for establishing policies and practices.

DOT Action Plan

In order to promote reductions in the numbers of accidents and fatalities at grade crossings, the FHWA, the FRA, the Federal Transit Administration (FTA), and the National Highway Traffic Safety Administration (NHTSA) published the *Rail–Highway Crossing Safety: Action Plan Support Proposals* (hereinafter called the Action Plan).[45] In this 1994 Action Plan, the modal administrations identify six major initiatives through which safety at all grade crossings could be improved:

- Increased law enforcement of traffic laws at crossings,
- Reviews of safety improvements at rail crossing corridors,
- Increased public education and Operation Lifesaver,[46]
- Safety at private crossings,
- Data and research, and
- Trespass prevention.

Within these major initiatives, the Action Plan identified 55 individual proposals, including those targeting specific needs, such as increasing truckdriver and busdriver awareness of crossing safety, as well as those providing incentives to advance a program. Proposals pertinent to this study on the safety at passive grade crossings will be discussed in appropriate sections of this report.

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[44] American Railway Engineering Association. 1996. Manual for railway engineering. Washington, DC. Multiple vols.

[45] U.S. Department of Transportation, Federal Highway Administration; Federal Railroad Administration; Federal Transit Administration; National Highway Traffic Safety Administration. 1994. Rail-highway crossing safety: action plan support proposals. Washington, DC: Federal Railroad Administration. 52 p.

[46] Operation Lifesaver is identified and discussed later in this chapter.

DOT Study of Locomotive Conspicuity

In July 1995, the FRA published the results of a study on locomotive conspicuity conducted by the Research and Special Programs Administration, John A. Volpe National Transportation Systems Center (Volpe Center).[47] Staff of the Volpe Center conducted field tests to determine the effectiveness of various external visual alerting devices designed to improve the ability of a motorist to detect a train at a crossing by making the locomotive more conspicuous. The results of this testing suggested that the number of accidents at grade crossings could be reduced through the installation and use of auxiliary alerting light systems, such as crossing lights, placed on the locomotive so as to create a triangular visual pattern with the headlight. In the spring of 1996, following publication of the study, the FRA issued a final rule in which the locomotive safety standards (in 49 CFR 229.125) were amended to include a requirement for auxiliary alerting lights: locomotives operated over public grade crossings at speeds greater than 20 mph must be equipped with auxiliary lights. Railroads had to comply with the regulation by December 31, 1997.[48]

DOT Grade Crossing Safety Task Force

In November 1995, following the accident that occurred in October 1995 in Fox River Grove, Illinois,[49] in which seven high school students were killed when their school bus was struck by a commuter train, the DOT formed an interagency task force to review the processes for designing and operating grade crossings. Members of the task force include representatives from the FRA, the FHWA, the NHTSA, the FTA, and the Office of Intermodalism. The Safety Board also provides a representative. The task force is focusing on the following five problem areas:

[47] U.S. Department of Transportation, Federal Railroad Administration. 1995. Safety of highway-railroad grade crossings: use of auxiliary external alerting devices to improve locomotive conspicuity. DOT/FRA/ORD-95/13; DOT-VNTSC-FRA-95-10. Washington, DC. Variously paged.

[48] Locomotives with visibility measures in compliance with interim rulemaking were “grandfathered” for 4 years after the date of the final rule. (Federal Register, Vol. 61, No. 45, dated March 6, 1996, pages 8881-8882.)

[49] National Transportation Safety Board. 1996. Collision of Northeast Illinois Regional Commuter Railroad Corporation (METRA) train and Transportation Joint Agreement School District 47/155 school bus at railroad/highway grade crossing in Fox River Grove, Illinois, on October 25, 1995. Highway Accident Report NTSB/HAR-96/02. Washington, DC. 74 p.

1. Interconnected highway traffic signal and highway–rail crossing warning devices (interconnected signals);
2. Available storage space for motor vehicles between highway–rail crossings and adjacent highway–highway intersections (storage space);
3. High-profile crossings and low-clearance vehicles (high-profile crossings);
4. Light rail transit crossings (light rail); and
5. Special vehicle operating permits and information (special vehicles).[50]

The task force is not addressing issues specifically related to safety at passive crossings.

Previous Safety Board Activity

The Safety Board has had a longstanding concern about grade crossing safety. Since its creation in 1967, the Board has investigated more than 400 accidents, including the 60 accidents investigated for this study, occurring at grade crossings. The Safety Board has also conducted several studies on grade crossing safety. In 1981, the Board issued a safety effectiveness evaluation on the improvement of nighttime conspicuity of railroad trains,[51] and a special study on grade crossing accidents involving trucks transporting bulk hazardous materials.[52] In 1985, the Board conducted a grade crossing review for calendar years 1983 and 1984.[53] In 1986, the Board completed a safety study on passenger/commuter train and motor vehicle collisions at grade crossings.[54] Based on the results of these accident investigations and studies, the Safety Board has issued about 100 safety recommendations relevant to grade crossings; 14 of these recommendations were specifically aimed at passive grade crossing safety and are discussed where appropriate in this report.[55] These recommendations have resulted in many improvements to grade crossing safety.

[50] U.S. Department of Transportation. 1996. Accidents that shouldn't happen. Washington, DC. 15 p.

[51] National Transportation Safety Board. 1981. The improvement of nighttime conspicuity of railroad trains. Safety Effectiveness Evaluation NTSB/SEE-81/03. Washington, DC. 45 p.

[52] National Transportation Safety Board. 1981. Railroad/highway grade crossing accidents involving trucks transporting bulk hazardous materials. Special Study NTSB/HZM-81/02. Washington, DC. 48 p.

[53] National Transportation Safety Board. 1985. Railroad/highway grade crossing review—calendar years 1983 and 1984. Safety Study NTSB/SS-85/05. Washington, DC. 65 p.

[54] National Transportation Safety Board. 1986. Passenger/commuter train and motor vehicle collisions at grade crossings (1985). Safety Study NTSB/SS-86/04. Washington, DC. 210 p.

[55] A summary of these 14 recommendations and the status of each is included in appendix C.

In 1972, the Union Pacific Railroad created a program that brought Idaho State agencies and the railroad together to address grade crossing safety through public education; this program was called Operation Lifesaver. The Safety Board recognized the value of these efforts, and in 1977 issued Safety Recommendation H-77-25, asking the National Safety Council to serve as the coordinator for the total development, implementation, and evaluation of a nationwide Operation Lifesaver railroad–highway grade crossing program.[56] Primarily as a result of the Safety Board's recommendation and aggressive followup, by the mid-1980s, 48 States had established Operation Lifesaver programs. In 1986, the national program was established as an independent nonprofit organization, and it currently operates on a budget of about $1 million, half of which is funded by the Federal government.[57]

The Safety Board investigated accidents at Intercession City, Florida, and in Sycamore, South Carolina, where large, low-riding trucks became lodged on the tracks at passive grade crossings and were struck by passenger trains.[58] Issues revealed in these investigations led the Safety Board to recommend improved signs to warn drivers of the hazards presented by high profile (hump) crossings,[59] and to recommend that railroads implement 24-hour toll-free emergency telephone systems that motorists can use to warn the railroads when a hazardous condition exists at a crossing.[60] As a result of these recommendations, the FHWA added a new sign to the MUTCD to warn of a hump crossing, and several States and railroads are acting to install signs at all grade crossings that provide an emergency phone number.

[56] This recommendation was classified "Closed—Acceptable Action" when the National Safety Council accepted the responsibility for the first national Operation Lifesaver program in 1979.

[57] The program is maintained by coordinators in each State, each of whom is supported by many volunteers who give speeches and presentations to the public. Railroads, automobile associations, States, safety associations and others historically have provided infusions of human resources and monies to keep the program running smoothly. The FRA, the FHWA, and the Safety Board are among the Federal agencies that participate in Operation Lifesaver activities.

[58] (a) National Transportation Safety Board. 1995. Collision of Amtrak train No. 88 with Rountree Transport and Rigging, Inc., vehicle on CSX Transportation, Inc., railroad near Intercession City, Florida; November 30, 1993. Highway Accident Report NTSB/HAR-95/01. Washington, DC. 72 p. (b) National Transportation Safety Board. 1996. Highway/rail grade crossing collision near Sycamore, South Carolina; May 2, 1995. Highway Accident Report NTSB/HAR-96/01. Washington, DC. 96 p.

[59] Safety Recommendation H-96-5 to the FHWA is classified "Open—Acceptable Response."

[60] Safety Recommendation R-96-3 is currently classified "Open—Acceptable Response" for 2 of the Class I railroads; "Closed—Acceptable Action" for 1 of the railroads; "Open—Initial Response" for 1 of the railroads; and "Open—Awaiting Response" for 6 of the 10 Class I Railroads. In April 1998, the Safety Board sent followup letters to the 6 railroads that had not responded to the recommendation. Safety Recommendation R-96-2 to the American Short Line Railroad Association is classified "Open—Awaiting Response."

In addition to the above activities, the Safety Board has issued other recommendations over the years that have addressed nighttime conspicuity of trains, the clearing of vegetation in the crossing vicinity, additional warning devices to be placed at passive crossings scheduled for and awaiting upgrade to active devices, the enforcement of stop signs at grade crossings, and the audibility of train horns. Pertinent recommendations will be discussed, where appropriate, in this report.

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Chapter 3

Methods and Overview of the Accident Sample

For this study, the Safety Board (1) investigated 60 grade crossing accidents and (2) obtained information during a public forum convened in May 1997 in Jacksonville, Florida. This chapter provides a description of the study design and the data collection method, and an overview of the accident sample.

Study Cases

Selection and Notification Criteria

The Safety Board selected for study accidents involving a collision between a train and a highway vehicle occurring at a passive grade crossing, wherein the highway vehicle was sufficiently damaged to require towing. To ensure timely accident investigations, qualifying accidents were limited to those occurring in States with close proximity to the Safety Board's regional offices located in California, Georgia, Illinois, New Jersey, and Texas.

Accidents meeting the qualification criteria were accepted sequentially for investigation from December 1995 through August 1996, as the Safety Board received notification; 60 accidents met the criteria and were included in the study analysis.[61] The sample of accidents is not intended to be statistically representative of the entire population of accidents at passive grade crossings during the study period, but rather to illustrate a range of passive grade crossing accidents.

Investigative Procedures

The Safety Board used its standard investigative procedures for these accidents, obtaining detailed information about the crossing area, the vehicles involved, and the vehicle occupants. A probable cause was determined for each accident in the study. Although the accident scene was not typically secured for the Board's investigators, there was an inspection of each accident site and of the vehicles involved.[62]

[61] Two additional accidents were investigated (cases 2 and 24) but were determined not to meet the qualification criteria; therefore, they were excluded from the analysis.

[62] The locomotive involved in case 58 was dispatched from the accident scene prior to the investigator's arrival.

In addition to collecting general information about the accident, Safety Board investigators gathered detailed data about the alignment, construction, and condition of both the roadway and the railroad tracks at the crossing. Information about the presence and condition of signs or pavement markings near the crossing was collected, as well as the traffic frequency counts for both highway and railroad traffic. In the event that the vertical profile of a given accident crossing was inconsistent with the guidelines set forth by AASHTO,[63] the investigators took detailed measurements of the crossing elevation from the roadway. Investigators also documented the location of any objects they determined to be sight obstructions for the highway vehicle driver. The investigators examined the methods used on each accident train, such as the use of lights or reflective material, designed to make the train easier for a motorist to see both during the day and at night.

When possible, Safety Board investigators conducted interviews with the person operating the train at the time of the accident, and with the driver of the highway vehicle. These interviews provided information on their perceptions, not only of the accident itself, but also of the surrounding area and the traffic control system in place at the crossing.

Public Forum

In May 1997, the Safety Board convened a 2-day public forum in Jacksonville, Florida, to gather information about issues affecting safety at passive grade crossings. The agenda for the public forum is given in appendix D. Witnesses included experts from the railroad industry; law enforcement; research groups; Operation Lifesaver; and Federal, State, and local government agencies. Those involved in grade crossing accidents, both highway vehicle occupants and traincrews, testified about their personal experiences. In addition, representatives from Canada and Italy discussed passive grade crossing issues and experiences in their countries.

The topics addressed at the forum included public education, the role of the media, physical characteristics of passive grade crossings, communications between railroad and highway officials, crossing closures, and Federal versus State responsibility for grade crossing safety. Testimony from the public forum will be discussed in the relevant sections later in this report.

[63] AASHTO guidelines recommend that the roadway surface be no more than 6 inches lower or 3 inches higher than the top of the tracks at 30 feet away from the nearest track. (AASHTO (1990, pages 842-843).)

Overview of the Accident Sample

This section provides general information about the 60 accidents in the Safety Board's sample.[64] Details regarding the crossings at which the accidents occurred are reported in chapter 4.

Time of Day

Most of the accidents occurred during the daylight hours (47 of 60, or about 78 percent). In comparison, in 1996, about two-thirds of all accidents (1,213 of 1,817) at public passive grade crossings occurred during daylight.[65] Because certain issues pertain to nighttime accidents specifically, the investigators made an effort to investigate a number of accidents that would help illustrate these issues; nighttime accidents were taken sequentially as the Board received notification.

Injury Severity and Fatalities

More than half the highway vehicle drivers (35 of 60) and highway vehicle passengers (16 of 25) were fatally injured (table 3–1). The injury distribution seen in the study case accidents, however, is not necessarily representative of the injury distribution in all passive grade crossing accidents; the Safety Board is more likely to receive notification of an accident if there are serious or fatal injuries involved. According to FRA data for 1996, about 12 percent (209 of 1,817) of all accidents at public passive grade crossings involved a fatality.[66]

Crossing

Of the 60 accidents, 46 occurred at crossings on public roads and 14 occurred at crossings on private roads. These private roads provided access to farms (three accidents), residential neighborhoods (four accidents), commercial areas (three accidents), and industrial complexes (three accidents). The remaining accident was on a private road that was used by all traffic when a nearby underpass was flooded. Thirty-five of the accident crossings had a vertical profile outside the limits recommended by AASHTO. Of the 60 crossings in the study, 19 were not posted with the DOT crossing identification (ID) number, and 2 were posted with an incorrect ID number.[67] Information on the signs and pavement markings present at the study accident crossings is discussed in the next chapter.

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[64] The study case number, date, and location of each accident are provided in appendix E, table E–1. Appendix E also contains additional tables summarizing data from the accident sample. Volume 2 of this report contains a narrative summary of each of the 60 accidents.

[65] U.S. Department of Transportation, Federal Railroad Administration. 1997. Highway-rail crossing accident/incident and inventory bulletin. No. 19. Washington, DC. 87 p. (page 43).

[66] FRA (1997, page 43).

[67] The FRA requires that reports of accidents occurring at grade crossings must include the crossing's unique DOT crossing ID number, and recommends that every crossing be posted with its ID number.

Table 3–1. Number of persons injured in the 60 study accidents, by injury severity.

Person involved	Injury severity: Minor	Serious	Fatal	Number not injured	All persons involved
Highway vehicle driver	9	5	35	11	60
Highway vehicle passenger	3	2	16	4	25
Train crewmember	4	0	0	189	193
Train passenger	4	0	0	1,536	1,540
Total	20	7	51	1,740	1,818

Highway Vehicle Driver/Vehicle

Thirty-six drivers (60 percent) in the accident sample had no previous driving convictions within the 3 years prior to the study accident.[68] To put this in perspective, according to the NHTSA, 55.8 percent of the drivers involved in all fatal accidents involving highway vehicles in 1995 had no previous driving convictions in the same time period.[69]

Impairment because of drug or alcohol use was not common for the accident-involved drivers in the study. Of the 60 drivers, 27 were not tested, most commonly because the officers on the scene determined that there was no evidence to warrant testing. Of the 33 drivers who were tested for the presence of alcohol and other drugs in their system, 7 were found to have positive results. Information published by the NHTSA indicates that one-third of the drivers involved in fatal grade crossing accidents on public roadways had measurable amounts of alcohol in their bloodstream.[70] In the Board’s sample, however, only 1 of the 7 drivers with positive results was found to have had a measurable amount of alcohol in his bloodstream; that driver was 1 of the 39 drivers involved in a fatal accident.

[68] (a) Driving histories were not available for 2 of the 36 drivers because neither driver had ever held a driver’s license in any State. (b) In the driving histories of the accident-involved drivers, 20 drivers had previous speeding violations, 12 drivers had other previous violations, 7 drivers had a previous accident within 3 years of the study accident, and 3 drivers had previous convictions for driving under the influence. An individual driver may have had more than one prior driving conviction. One driver in the study had a suspended license.

[69] U.S. Department of Transportation, National Highway Traffic Safety Administration. 1996. Traffic safety facts. 192 p. (page 96).

[70] U.S. Department of Transportation, National Highway Traffic Safety Administration. 1994. Rail-highway crossing safety: fatal crash and demographic descriptors. NHTSA Technical Report DOT HS 808 196. Washington, DC. 61 p. (page 18).

Nineteen of the 60 highway vehicles were reported by the traincrews to be in motion at the time of impact, with no evidence of slowing or stopping.[71] In 16 cases, the highway vehicles reportedly either slowed and then proceeded, or were accelerating. Ten drivers reportedly stopped their vehicles, then proceeded onto the tracks. In four cases, the vehicles were either lodged or stalled on the tracks, and in five cases the vehicle was attempting to stop and came to a stop on the tracks. Four other highway vehicles were engaged in other actions,[72] and in two cases the action taken by the highway vehicle driver was unknown.

In three of the study accidents, the highway vehicle struck the side of a train already occupying the crossing (cases 8, 37, and 43). In all other cases, the train struck the highway vehicle.[73]

Train Conspicuity

Fifty-nine of the 60 accident-involved trains were determined to have had a headlight in use at the time of the accident.[74] Auxiliary alerting lights were installed on the locomotives in 42 of the accident trains, and in 36 of the cases these lights were in use. Twenty-five of the accident trains had reflective material on the locomotives to assist highway vehicle drivers in detecting trains at nighttime, particularly if the trains are already occupying the crossing. It is not known how many trailing cars in each consist were reflectorized, but 15 trains were reported as having some reflectorized trailing cars.

Train Speed

Train speed at impact (available from event recorders) was known for 56 of the study cases. The impact speed ranged from 3 to 80 mph.

Train Horn

In 55 of the 60 cases, the Safety Board was able to determine that the train horn sounded prior to impact.[75] The train horn was sounded in 14 of the 18 cases in which the Safety Board was able to interview the highway vehicle driver (table 3–2). Four of the 14 drivers in these cases reported that they heard the train horn before impact, but of these

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[71] (a) The Safety Board acknowledges that the accuracy of reports made by traincrews or surviving drivers is dependent on the ability (given memory limitations) and willingness of the individuals to provide accurate information. (b) Three interviewed drivers were among the 19 drivers reported to have proceeded without slowing or stopping; they corroborate the traincrews' reports.

[72] In case 3 the vehicle was reportedly backing off the tracks, in case 14 the vehicle was described as decelerating, and in case 51 the vehicle was in motion but whether accelerating or decelerating is unknown. The vehicle in case 43 struck the train, but whether it was accelerating or decelerating was not reported.

[73] According to FRA data for 1996, the highway vehicle struck the train in 432 of the 1,817 accidents at passive grade crossings (23 percent).

[74] The Safety Board was not able to determine the headlight use on the locomotive involved in case 56.

[75] Of the remaining five cases, the train did not sound its horn in one instance (case 8), and use of the train horn could not be determined in four other instances (cases 9, 30, 52, and 61).

Table 3–2. Recollections of 18 of the 60 highway vehicle drivers in the study cases about whether they heard the train horn and whether there were distractions at the time of the grade crossing accident.[a]

Case number	Train horn blown[b]	Driver heard horn[b]	Driver aware of oncoming train	Distraction identified
08				
09				
15	✔		✔	Unknown
22	✔			Stereo, passengers
25	✔			
26	✔	✔	✔	
27	✔	✔	✔	
28	✔		✔	Highway traffic
37	✔			Passengers
38	✔			Highway traffic
40	✔			Highway traffic
48	✔	✔[c]	Unknown	Unknown
52			✔	
54	✔	✔[c]	✔	Stereo
55	✔			Stereo
56	✔		✔	Passengers, loose items
57	✔			
58			✔	

[a] The remaining 42 drivers were not available to the investigators for interview.

[b] Determined by the accident investigator from data on event recorder, witness statements, or train engineer.

[c] Driver was outside vehicle at the time of the accident.

4 drivers, 2 were not inside their vehicle at the time of impact. Of the remaining 10 drivers, who reported that they did not hear the train horn, 3 indicated that they were still aware of the train's approach before impact.[76]

Eight of the 10 highway vehicle drivers who did not hear the train horn reported either internal and/or external sounds that distracted them from the horn's audibility. These distractions included the stereo, passengers, and traffic. Seven drivers had their vehicles' windows open, but four of these drivers still did not hear the train horn; two of these four drivers reported distractions.

[76] These three drivers stated that they saw the train but thought it was far away (case 15), or that they saw the train only after they were already on the tracks (cases 28 and 56).

Traincrew

The train operators had experience ranging from 1 year to more than 25 years of service. No member of any traincrew was determined by the investigating law enforcement officer to be impaired.

Driver and Engineer Interviews

Safety Board investigators were able to obtain interviews with 54 of the 60 engineers involved in the study accidents,[77] and with 18 of the 25 surviving highway vehicle drivers.

In interviews, 45 of the 54 engineers stated that they saw the highway vehicle prior to the crash, and 51 engineers reported applying the train brakes prior to or upon impact. The engineers in 8 cases reported that they believed the highway vehicle drivers saw the train, and in 12 cases believed the drivers did not see the train; the engineers in the remaining 25 cases were uncertain.

Probable Causes

The Safety Board determined the probable cause for all 60 accident cases investigated. Overall, driver error was cited as the primary cause in 49 of the 60 accident cases: driver disregard for the stop sign in 13 cases, and the driver's failure to look for a train in 16 cases (table 3–3). In 7 of the remaining 11 cases, the probable cause was determined to be related to roadway conditions that affected the driver's ability to detect the presence of a passive crossing or an oncoming train; roadway and track conditions were cited as the probable cause in 3 of the 11 cases.

[77] (a) The engineers involved in the six remaining accidents (cases 38, 39, 48, 50, 53, and 56) were dispatched from the accident scene prior to the investigator's arrival. (b) The Safety Board notes that in 6 of the 60 cases, the person at the train controls was not the engineer of record: in cases 3, 11, 31, and 55 it was the assistant engineer; in case 27 it was a certified engineer on a familiarization run; and in case 29 it was the fireman.

Table 3–3. Probable causes and contributing factors for the 60 study accidents at passive grade crossings.

Cause or contributing factor	Number of study accidents in which cited as primary cause	Number of study accidents in which cited as a contributing factor
Driver-related:		
Disregard for stop sign[a]	13	
Failure to look	16	
Distraction	10	2
Judgment error[b]	5	1
Inattention[c]	4	
Failure to follow procedure	1	
Fatigue		1
Drugs		1
Vehicle-related:		
Mechanical failure	1	
Environment-related:		
Roadway conditions	7	9
Roadway and track conditions	2	2
Inadequate signage	1	2
Train horn not sounded		2
Roadway and traffic conditions		1
Sun glare		1

[a] In case 46, the disregard for the stop sign was due to fatigue.

[b] In case 51, the driver's judgment error was due to alcohol impairment.

[c] The driver inattention in case 4 was possibly due to drug impairment.

Chapter 4

Description of the Accident Crossings: Detecting the Presence of a Passive Crossing and an Oncoming Train

This chapter describes the accident crossings, specifically the information given to motorists to advise them of the presence of a crossing and the physical characteristics at the accident crossings that may have affected the driver's ability to see the oncoming train.

Factors That Alert a Driver to the Presence of a Passive Crossing

At a passive grade crossing, the highway driver is alerted to the presence of a grade crossing by the set of pavement markings and traffic signs on the roadway leading to and at the grade crossing. These markings and signs are the same markings and signs that are present at active crossings, which, unlike passive crossings, have additional traffic control devices to alert the driver to the presence of a train. For example, railroad crossing advance warning signs and crossbuck signs are required at all public crossings. Multiple-track warning signs are also required at all crossings where there are multiple train tracks. Table 4–1 shows the number of passive crossings in the Board's sample where specific signs were required, and the number of crossings where they were present. Under certain conditions, the MUTCD suggests additional crossing-related signs and requires additional roadway-related signs; 27 crossings had additional signs present (table 4–2).

The total number of signs at each crossing approach ranged from 0 to 6; the total number of signs directly related to the presence of a grade crossing ranged from 0 to 3. Safety Board investigators documented the presence of 129 signs in the vicinity of the

Table 4–1. Required grade crossing signs present on the roadway approaches to the 60 study accident crossings.[a]

Grade crossing sign required	Public crossings		Private crossings	
	Number of crossings where required	Number of crossings where present	Number of crossings where required	Number of crossings where present
Crossbuck	46	45[b]	1[c]	9
Railroad advance warning	46	22	0	0
Multiple tracks	7	5	0	1

[a] Federal Highway Administration requirements for grade crossing signs at public crossings are contained in the *Manual on Uniform Traffic Control Devices* (MUTCD). Of the 60 study cases, 46 involved public grade crossings and 14 involved private grade crossings, which are not subject to Federal requirements for grade crossing signs.

[b] The public grade crossing in case 41 did not have a standard crossbuck. Instead, it had an experimental sign referred to as an "Ohio buckeye" crossbuck. This sign has red lettering, reflectorized strips the full length of the mast, and a supplemental shield bearing red chevrons and the word "Yield."

[c] The State of Florida requires a crossbuck sign at all public and private crossings.

Table 4–2. Optional grade crossing signs and required roadway-related signs present on the roadway approaches to the 60 study accident crossings.

Sign	Number of crossings where present
Optional grade crossing sign:[a]	
Stop	22
Stop ahead	3
No passing zone	1
Required roadway-related sign:[b]	
Chevron	3
T intersection	2
Speed limit	1
No trucks	1
Left reverse turn	1
Bump	1

[a] Federal Highway Administration requirements for grade crossing signs at public crossings are contained in the *Manual on Uniform Traffic Control Devices* (MUTCD). The manual also addresses the appearance and size of optional grade crossing signs that may be used at public crossings. The 14 private crossings involved in the National Transportation Safety Board study cases are not subject to Federal requirements for grade crossing signs.

[b] Signs are present because of circumstances of the roadway. These signs are not related to the presence of a grade crossing.

accident grade crossings; 110 of these were related to the presence of the grade crossing.[78] Twenty-three of the 110 crossing-related signs were not in good condition; many of these signs had a combination of problems that made them difficult to be seen, including being faded, dirty, bent, broken, punctured, or not aligned with the roadway. One hundred thirteen masts supported the 129 signs, and all but five of the masts were free of sight obstructions.

Pavement Markings

Of the 60 roads approaching the accident crossings, 45 were surfaced with asphalt, 1 was concrete, and 14 had either gravel or earthen surfaces. Nineteen of the 46 paved roads were required to have the full set of railroad crossing pavement markings described in the MUTCD (illustrated in figure 4–1) because they were paved public roads with a traffic speed above 40 mph.[79] Four of these 19 roads bore a full set of pavement markings, 4 others bore partial sets of pavement markings, and the remaining 11 roads had no pavement markings (table 4–3). The FRA inventory indicates that 75 percent of public crossings, both active and passive, with paved roadway approaches have pavement markings present, but it does not indicate how many of the roads without pavement markings were exempt from the requirement.

The full set of pavement markings was not required on the remaining 27 paved roads in the accident sample because either the prevailing speed was less than 40 mph or they were private roads. Full or partial pavement markings were present, however, on 11 of these roads. According to the MUTCD, "[w]hen used, a portion of the pavement marking symbol should be directly opposite the advance warning sign."[80] Of the 19 roads with full or partial pavement markings (8 where the full markings were required, 11 where full markings were not required), 5 had markings that were placed in accordance with the MUTCD near the advance warning sign (cases 7, 9, 32, 41, and 44), and 8 had pavement markings that were placed too close to the crossing, with the marking at one crossing ending only 15 feet away from the tracks (case 8). In three cases, there were pavement markings but no advance warning sign (cases 10, 36, and 57). In addition, the pavement markings on 10 of the 19 roads were worn and not in good condition.

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[78] Ten of the 129 signs in the vicinity of the accident crossings were not listed in the MUTCD; thus, Federal standards for these signs do not exist, and the States are not required to have the signs. Although 5 of the 10 unlisted signs were directly related to the presence of a grade crossing, they have not been counted in the 110 signs.

[79] The MUTCD requires both the "no passing zone" line and the railroad crossing pavement marking, (which consists of an "X," the letters "RR," and certain transverse lines) in advance of the crossings on paved public roads where the prevailing speed is higher than 40 mph.

[80] MUTCD (1988, page 8B-4).

Figure 4–1. Full set of pavement markings on a roadway approach paved with either asphalt or concrete and with a traffic speed over 40 mph: “X,” “RR,” transverse lines, and no-passing zone lines. Some portion of the pavement markings should be directly opposite the advance warning sign but no closer than 50 feet from the crossing.

Table 4–3. Pavement markings present on the roadway approaches to the 46 study accident crossings on paved roads.

Pavement markings	Number of crossings where present and a full set of railroad crossing pavement markings was— Required[a]	Not required[b]
Full set of railroad crossing pavement markings	4	7
No-passing zone line only	0	2
Railroad crossing pavement marking only	4	2
No pavement markings	11	16
Total	19	27

[a] The Federal Highway Administration's *Manual on Uniform Traffic Control Devices* requires a set of pavement markings on paved public roads where the prevailing speed is higher than 40 mph. The set comprises a no-passing zone line and the railroad crossing pavement markings (an "X," the letters "RR," and certain transverse lines) in advance of the crossing.

[b] The full set of pavement markings was not required on the roadway approaches to these crossings because either the prevailing speed was less than 40 mph or they were private roads.

Advance Warning Sign

The 46 public crossings in the accident sample were required to have a circular railroad crossing advance warning sign (figure 4–2); 24 crossings did not display the sign.[81] The 14 private crossings were not required to, and did not have, the advance warning sign. Eight of the 24 public crossings without the advance warning sign had stop signs, but the MUTCD does not cite the presence of a stop sign as cause for exemption from using the circular advance warning sign. According to the MUTCD, the railroad advance warning sign need not be used under the following circumstances:

> On low-volume, low-speed roadways crossing . . . tracks . . . infrequently used and . . . flagged by crews;
>
> In the business districts of urban areas . . . [where] active grade crossing traffic control devices are in use;
>
> . . . [where] physical conditions do not permit even a partially effective display of the sign."[82]

[81] The MUTCD requires the presence of the railroad advance warning sign at public grade crossings far enough in advance of the crossing to allow a driver to "perceive, identify, decide, and perform any necessary maneuver." The minimum recommended distance is 100 feet from a crossing.

[82] MUTCD (1988, page 8B-3).

Figure 4–2. Circular railroad crossing advance warning sign.

None of the 24 public crossings without the circular advance warning sign met the exemptions specified in the MUTCD. According to FRA data, about 61 percent of all active and passive crossings are equipped with the circular advance warning sign.

A 1990 study sponsored by the Texas Department of Transportation surveyed a number of highway vehicle drivers who had just passed through one of several test crossings in Texas. When asked, 51 percent of the responding drivers were able to correctly indicate the meaning and position of the circular advance warning sign.[83] One of the researchers later reported that 50 percent of drivers surveyed were not aware that the advance warning sign is used at both active and passive grade crossings.[84] The Safety Board asked the drivers in its study cases what signs were present in the crossing vicinity; of the three drivers interviewed whose crossings were equipped with the advance warning sign, only one remembered the presence and meaning of the sign.

[83] Bartoskewitz, Richard T.; Fambro, Daniel B. 1995. Passive signing research in Texas. In: Proceedings, 3rd international symposium on railroad-highway grade crossing research and safety; 1994 October 24-26; Knoxville, TN. Knoxville: University of Tennessee: 75-90 (page 88).

[84] Presentation to Safety Board staff at a session held in Knoxville, Tennessee; January 23-26, 1996.

Figure 4–3. Crossbuck sign, multiple tracks sign, and stop sign placed at a crossing.

Crossbuck Sign

The crossbuck is a regulatory sign and was required at the 46 public crossings in the Safety Board's accident sample and at 1 of the private crossings.[85] The sign was present at 45 of the public crossings, at the 1 private crossing where it was required, and at 8 private crossings where it was not required (figure 4–3). Thus, crossbuck signs were present at 54 of the 60 accident crossings to advise the highway vehicle driver of a grade crossing. Five of the six crossings without the standard crossbuck were on private roads; the sixth, a public crossing, had a special, nonstandard, experimental crossbuck configuration.[86] The FRA data do not indicate whether crossbuck signs were present at a crossing, but they do indicate that in 1996, 31 percent of the public passive grade crossings did not meet the MUTCD standards for the crossbuck sign.[87]

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[85] The State of Florida requires a crossbuck sign at all public and private grade crossings.

[86] The crossbuck in case 41 is referred to as an "Ohio buckeye" crossbuck. The sign had red lettering, reflectorized strips the full length of the mast, and a supplemental shield bearing red chevrons and the word "Yield." A report on the results of an extensive field test of this experimental configuration throughout Ohio is scheduled for publication in the fall of 1998.

[87] This number includes crossings with no crossbuck sign and crossings where the crossbuck is not reflectorized.

Table 4–4. Meaning of the crossbuck and driver action required by the crossbuck according to the accident-involved highway vehicle drivers at 18 of the 60 study accident crossings.[a]

Perceived meaning and action required	Number of drivers who indicated the crossbuck meaning or action
Meaning of the crossbuck:	
At a crossing now	10
Crossing ahead	7
Other	1
Action required by the crossbuck:	
Stop	6
Yield	5
Slow down	4
No special action	2
Other	1

[a] The remaining 42 drivers were not available to the investigators for interview.

Investigators asked the 18 accident drivers they interviewed what action the driver thought was required by a crossbuck (table 4–4). Most (n = 10) of the drivers believed that the crossbuck indicated the presence of tracks. Of the 18 drivers interviewed, 5 responded that a crossbuck required a driver to yield to a train, and 6 responded that a crossbuck required a driver to stop. No States include in their motor vehicle codes any special rules dictating what driver actions are to be taken when encountering a crossbuck sign. Most States require the driver to slow down upon approaching a crossing and to be prepared to stop.[88] Although the crossbuck does not dictate the action required of a driver, nor is it stated in any guidance what action is dictated by the crossbuck, the crossbuck sign is widely recognized by motorists as indicating the location of a grade crossing. In a 1988 study of motorist understanding of traffic control devices, 76.3 percent of the interviewed drivers identified the crossbuck as the sign placed at a crossing.[89]

[88] Jennings, L. Stephen, comp., ed. 1995. Compilation of State laws and regulations affecting highway-rail grade crossings. 2nd ed. Washington, DC: Federal Railroad Administration. Variously paged.

[89] Richards, Stephen H.; Heathington, K.W. 1988. Motorist understanding of railroad-highway grade crossing traffic control devices and associated traffic laws. In: Traffic control devices 1988. Transportation Research Record 1160. Washington, DC: Transportation Research Board, National Research Council: 52-59.

Multiple Tracks Sign

According to the MUTCD, sign masts at public crossings with multiple train tracks must bear, in addition to the standard crossbuck sign, an auxiliary sign to notify the motorist of the number of tracks (figure 4–3). Seven of the study crossings required the sign; five of the crossings had it. Five additional crossings with multiple tracks were on private roads and were not required to have the sign; four of these private crossings did not have the sign. The following accident illustrates the dangers presented to drivers at crossings with multiple tracks.

About 9 p.m. on Wednesday, May 29, 1996, a northbound National Railroad Passenger Corporation (Amtrak) train struck an eastbound Ford pickup truck on the No. 1 mainline track at the 2nd Street grade crossing in Lula, Georgia (case 29). According to the locomotive event recorder, the Amtrak train horn was sounded prior to the crossing; according to the traincrew, the headlight and auxiliary locomotive alerting lights were illuminated. A witness to the accident stated that he observed the pickup stopped at the crossing, awaiting the passage of a freight train on the nearer of two sets of tracks. The only indication given to the pickup driver that there was a second set of tracks was the small auxiliary sign below the crossbuck, the view of which was obscured by a “no trucks” sign on another mast. When the last car of the freight train cleared the crossing, the pickup driver moved to cross the intersection and was struck by the Amtrak train on the second set of tracks. The pickup driver was fatally injured; the traincrew and passengers on the train were not injured. According to FRA data for 1996, about 24 percent of the public passive crossings had more than one set of railroad tracks, but there is no information about whether these crossings were equipped with the multiple tracks sign.

Stop Sign

At 22 of the 60 passive grade crossings in the study, stop signs were in place at the time of the accident (figure 4–3). At these 22 crossings, traincrews reported that 11 highway vehicle drivers made no effort to stop (6 drivers proceeded without stopping or slowing, 4 slowed, and 1 accelerated); 5 stopped before proceeding; 3 stopped on the tracks; 2 were stalled on the tracks; and actions taken by 1 driver were unknown.

The 1988 edition of the MUTCD directed that stop signs be installed at grade crossings only after an engineering study had specifically determined that it was necessary and appropriate. The FHWA revised the MUTCD, pursuant to the passage of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), to state that “STOP or YIELD signs may be used at highway–rail grade crossings, at the discretion of the responsible State or local jurisdiction, for crossings that have two or more trains per day and are without automatic traffic control devices.”[90]

[90] FHWA final rule docket No. 92-11 (47 FR [Federal Register] 53029). The rule was effective November 6, 1992.

Table 4–5. Percentage of public passive grade crossings equipped with stop signs compared with the percentage of accidents at public passive grade crossings with stop signs, 1992–1996.[(a)]

Year	Percent public passive grade crossings with stop signs	Percent public passive grade crossing accidents at crossings with stop signs
1992	9.94	13.28
1993	10.08	13.61
1994	10.84	15.33
1995	11.10	19.84
1996	11.19	20.36

[(a)] Prior to 1992, the FRA used a different definition of a stop sign-equipped crossing; therefore, statistics for earlier years are not comparable to statistics for 1992–1996.

According to the annual FRA crossing inventory bulletins, the percentage of public passive grade crossings that are equipped with stop signs has increased from 9.94 percent in 1992 to 11.19 percent in 1996. In that same period, the percentage of accidents involving public passive crossings with stop signs increased from 13.28 percent to 20.36 percent of accidents at all public passive crossings (table 4–5). The relatively small increase in the number of public passive grade crossings with stop signs may reflect a tendency by highway engineers to place stop signs only at the crossings judged to be more dangerous. The Safety Board does not have information on the number of highway vehicles that avoided being in a collision with a train when the vehicle driver stopped at a crossing with a stop sign. Nor does the Safety Board have information about whether the stop signs were installed at crossings with a high frequency of accidents or information on possible changes in highway or train traffic, and whether these factors could have affected the accident rates at the public passive crossings that are equipped with stop signs. Therefore, the effectiveness of stop signs cannot be evaluated based on the information from the FRA. The report addresses the role of stop signs at passive crossings in more detail in chapter 6.

Reflectorization of Signs

Currently, the MUTCD requires that the crossbuck sign be reflectorized, but there is no requirement regarding reflective material on the sign masts. Forty-five of the 54 standard crossbuck signs at the study crossings were reflectorized, but only 11 of the crossbuck sign masts had any reflectorization. Only one of the 11 sign masts was equipped with strips of reflectorized tape extending the mast's full length on both the front and back of the mast (case 41); this mast was the one supporting the experimental Ohio buckeye crossbuck and shield. The remaining 10 masts had small rings of tape, small reflectorized panels, or reflective buttons. Accidents in the study sample occurred during darkness or twilight at 13 crossings: 9 with reflectorized crossbuck signs, and 5 with reflectorized sign masts.

The height of the crossbuck can affect a driver's ability to see the sign at night. According to the MUTCD, the standard placement for a crossbuck is with the sign center 9 feet from the ground,[91] a height that may be altered if local conditions dictate. Table 4–6 shows the height to the center of the crossbuck at the 54 study accident crossings with crossbuck signs: about 43 percent are between 8 and 9 feet or between 9 and 10 feet. A considerable number of the crossbuck signs, however, were centered at 10 feet or higher (46 percent). This height becomes questionable when considering the sign's visibility to drivers at night. A 1993 study sponsored by the FRA shows that the standard placement of the crossbuck is too high to be effectively illuminated by typical automobile low-beam headlights and recommends that the crossbuck be lowered 2 feet, to about 7 feet.[92] As table 4–7 shows, of the 13 crossings where accidents occurred during twilight or darkness, all but one had the crossbuck centered at or above 8 feet—too high to be effectively illuminated by low-beam automobile headlights, according to the 1993 FRA study.

When a slow-moving train occupies a crossing at night, it can be difficult for a motorist to discern that the crossing is not clear. If the crossbuck masts are fully reflectorized on both the front and the back, a motorist may be able to see the reflective back of the mast on the far side of the grade crossing flicker as the train cars pass. Further, when the angle of the crossing is skewed, the view of reflective material high on the crossbuck mast on the far side of the crossing may be obscured by the train cars, but the reflection from the material at the base of the mast would still be visible from underneath the train cars, an effect that could be further enhanced by the presence of reflective material on all sides of the mast.

According to research by the Virginia Transportation Research Council (VTRC), even in the event that a crossbuck can be seen at night, the most common configuration—a reflectorized crossbuck on an unreflectorized mast—can leave motorists with the impression that the sign is "floating."[93] Researchers at Kansas State University suggest reflectorization of the mast to which a crossbuck is attached as a way of giving more information to motorists about the exact location of a grade crossing.[94] The VTRC research shows that reflective strips the full length of both the front and back of the mast

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[91] MUTCD (1988, page 8B-2).

[92] Russell, E.R.; Kent, W. 1993. Highway-rail crossing safety demonstrations. Washington, DC: Federal Railroad Administration. 266 p. (page 101).

[93] Brich, S.C. 1995. Investigation of retroreflective sign materials at passive railroad crossings. Charlottesville, VA: Virginia Transportation Research Council. 35 p. (page 12).

[94] Russell, Eugene R.; Rys, Margaret; Liu, Libo. 1997. A program to improve safety at typical railroad-highway grade crossings on low-volume, rural roads. In: Proceedings, 25th annual conference of the Canadian Society of Civil Engineering; 1997 May 27-30; Sherbrooke, Quebec, Canada. [Publisher unknown].

Table 4–6. Height from the road surface to the center of the crossbuck at the 54 study accident crossings with a standard crossbuck sign.[(a)]

Height to center of crossbuck (feet)	Number of crossbuck signs	Percent of the study crossings with a standard crossbuck
Less than 6	1	1.9
Between 7 and 8	4	7.4
Between 8 and 9	7	12.9
Between 9 and 10	16	29.6
Between 10 and 11	8	14.8
Between 11 and 12	10	18.5
Between 12 and 13	4	7.4
Above 13	1	1.9
Unknown	3	5.5

[(a)] The crossing in case 41(Pickerington, Ohio) had an experimental crossbuck; the height from the road surface to the center of the crossbuck was 9 feet.

Table 4–7. Height from the road surface to the center of crossbuck at the 13 study accident crossings where the accident occurred in nondaylight conditions.

Height to center of crossbuck (feet)	Number of crossbuck signs
5.5	1
8-9	3
9-10	4
12-13	1
Unknown	2
Not applicable	2

best provide this information.[95] In addition, anecdotal evidence indicates that reflective strips on all four sides of a wooden sign mast may be beneficial in situations where the roadway approach is curved or when drivers are approaching on nearby intersections. Further, some train engineers have reported that in foggy conditions they have been unable to see a whistle post indicating the upcoming crossing, but they have seen the reflectorized sign masts.[96]

[95] Brich (1995, page 15).

[96] Conversation with VTRC study manager on November 25, 1997.

Figure 4–4. “Ohio buckeye” crossbuck, an experimental configuration.

The experimental crossbuck configuration present at the grade crossing in study case 41, the Ohio buckeye crossbuck (figure 4–4), may solve some of the nighttime visibility problems inherent in the standard crossbuck configuration. Reflective strips extend the full length of both the front and back of the sign mast. In addition, a reflective shield is placed below the crossbuck at a height that may be better illuminated by automobile low-beam headlights. The sides of the shield are also angled to catch light from the headlight of an oncoming train and reflect that light toward an oncoming highway vehicle. The lettering and chevrons are printed in red, rather than black, to enhance daytime visibility. The crossing in case 41 was one of about 3,700 grade crossings in Ohio where this crossbuck configuration was being tested; the testing concluded in December 1997, and the report will be published in the fall of 1998.[97] The Safety Board looks forward to reviewing the report on the effectiveness of the buckeye crossbuck, and depending on the results of the Ohio study, may issue recommendations about the buckeye crossbuck in the future.

[97] Other States, including Idaho, are testing similar configurations.

Physical Characteristics at Passive Crossings That Affect a Driver's Ability To See a Train

For each accident crossing, the Safety Board examined physical characteristics at passive grade crossings that affect a driver's ability to see a train: (1) the sight distance available to the highway vehicle driver, (2) the angle at which the roadway meets the railroad tracks, and (3) curves on the roadway or railroad tracks.

Sight Distance

Sight distance is the technical term describing the set of distances along the highway and along the railroad tracks needed by a motorist to detect the presence of a train in time to stop. According to AASHTO, a grade crossing should be designed so that an approaching motorist is able to perceive the train, react to its presence, and stop the highway vehicle prior to the crossing. The required distance along the roadway (that is, from the vehicle to the crossing) and along the railroad tracks (from the crossing to the oncoming train) form two sides of a triangle. Together with the third side (an imaginary line from the train back to the highway vehicle) they form an area referred to as "quadrant sight distance," or the "sight triangle," the interior of which should be clear of any visual obstructions. For a vehicle stopped at the crossing, the driver must be able to see the train far enough along the tracks to have time to accelerate the vehicle and clear the crossing before the train's arrival.

The quadrant sight distance needed varies according to the speed of the train and of the highway vehicle, as well as the length and stopping distance of the highway vehicle. It is also affected by the angle at which the highway intersects the tracks and the slope of the roadway. When a grade crossing is designed, sight distances should be calculated by highway engineers. Figure 4–5 uses the study accident grade crossing in Doraville, Georgia (case 8), to illustrate the various sight distance requirements for a stopped vehicle (V1) and an approaching vehicle (V2).[98] A stopped vehicle will need more sight distance along the track (A) to see the oncoming train and cross the track before the train arrives, whereas a moving vehicle will need enough sight distance along the highway approach to the crossing (C) to see the train along the tracks (B) and to have time to stop.

[98] The Safety Board used AASHTO guidelines, identified in the "Guidelines" section of chapter 2, to calculate the sight distance at each of the study accident crossings. For purposes of this study, however, the Board assumed the design vehicle to be the highway vehicle involved in the study case accident. A highway engineer reviewed the formulas used to calculate the sight distances. Appendix E, table E–2 gives the calculated sight distance needed by the driver of a design vehicle approaching each of the 60 accident grade crossings and the sight distance available.

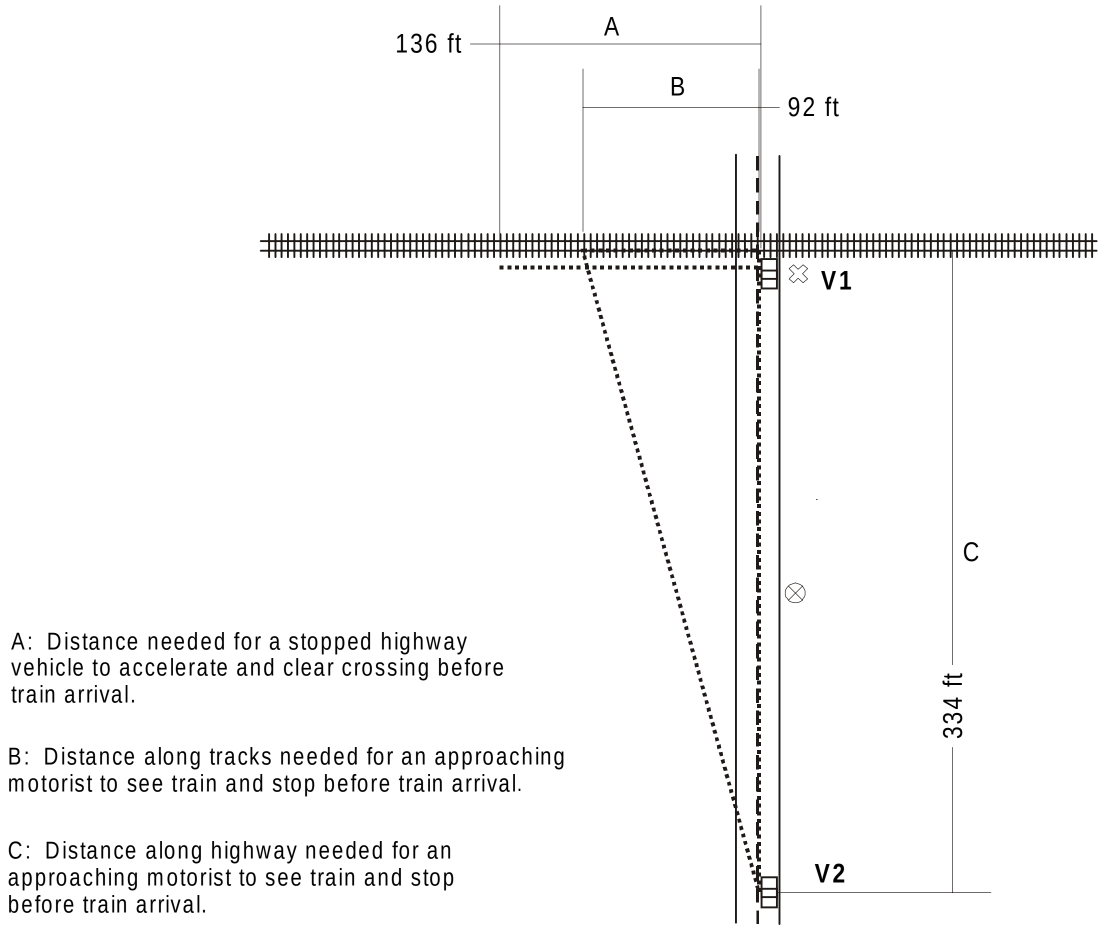

Figure 4–5. Illustration of sight distances required by a highway vehicle stopped at a grade crossing (V1), and by a highway vehicle approaching a grade crossing (V2).

The railroad track approaches at the accident crossings were generally straight, and the sight distance along the tracks that was available to the drivers of most types of highway vehicles stopped at the crossing stop line (such as V1 in figure 4–5) was, for the most part, adequate (n = 50). In 10 cases, however, there were sight obstructions for a driver stopped at a crossing: in 7 cases, vegetation restricted visibility; in 2 cases, curvature of the tracks restricted visibility; and in 1 case, a building restricted visibility.

The generally adequate sight distance for vehicles stopped at the crossings, however, did not hold true for motorists approaching the crossings (such as V2 in figure 4–5). In 33 cases, the grade crossing area afforded an approaching motorist less sight distance than was recommended by AASHTO guidelines.[99] At the majority of the crossings with limited sight distance (n = 24), the obstructions were trees, shrubs, or other types of plants: in one case, the trees were described as a forest (case 27); and in another case, the trees were fruit trees in an orchard (case 60). Six of the 33 cases had visual obstructions that included buildings, and in one of these cases the motorist's sight distance was obstructed by a hill. The following accident illustrates the potential consequences of inadequate sight distances for drivers of highway vehicles in motion.

About 8:15 a.m. on April 5, 1996, an eastbound Kansas City Southern freight train traveling about 40 mph struck a northbound Mazda at Golson Road near Calhoun, Louisiana (case 16).[100] The Mazda, traveling about 25 mph, which was about 10 mph below the posted speed limit, skidded onto the railroad tracks when the driver tried too late to stop her vehicle. The driver and her 8-year-old daughter in the right front seat of the car were both killed.

According to the AASHTO guidelines and based on the speeds of the highway vehicle and train in this case, the highway driver needed a clear sight triangle defined by a distance of 271 feet along the highway and 422 feet along the railroad tracks to see the train with enough time to safely stop the vehicle. However, because of the presence of a forested area on private property adjacent to the crossing, this sight triangle was not clear. As figure 4–6 illustrates, the driver in this case actually had a clear sight triangle with only 72 of the 271 feet needed along the highway and 112 of the 422 feet needed along the railroad tracks. By the time the driver saw the train and applied the brakes, she did not have enough time to stop the vehicle prior to the crossing.

In addition to calculating the sight distance for each of the 60 accident crossings, the Safety Board also examined each crossing in terms of the time an approaching motorist needs to safely stop the vehicle prior to the crossing compared with the actual time available, given the sight distance along the highway (appendix E, figure E–1). The differences in time needed compared with actual time available ranged from no shortage of time for some crossings to a shortage of 7½ seconds. For 18 (58 percent) of the crossings with limited sight distance, an approaching driver has only half or less of the time needed to safely negotiate the crossing. With such differences between the time needed and the time available, the driver's task to safely negotiate the crossing becomes more difficult. The Safety Board's study cases show a strong association between inadequate sight distance and accident occurrence.

[99] Three of the 33 crossings with limited sight distance for approaching motorists were on private roads.

[100] According to the traincrew, the headlight and auxiliary alerting lights were illuminated, and the train horn was sounded prior to the accident.

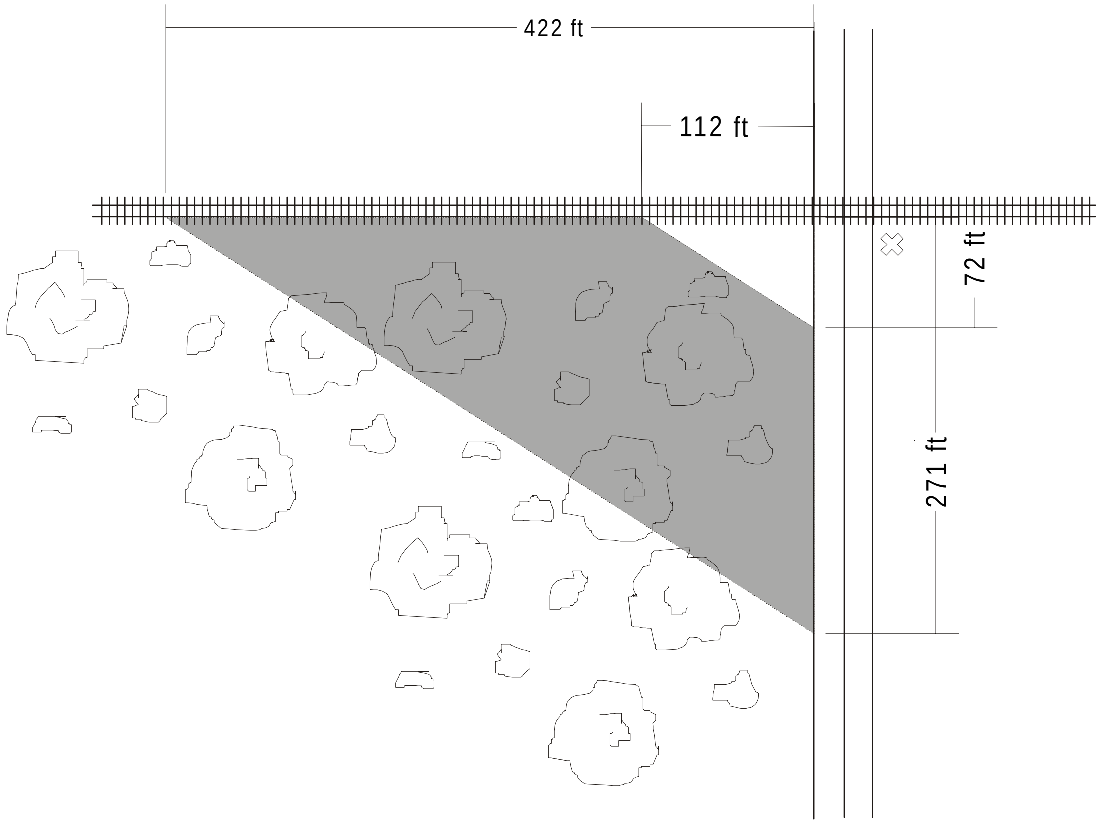

Figure 4–6. Sight distance needed (shaded area) versus the sight distance available at the accident crossing in Calhoun, Louisiana (case 16).

Angle of Intersection

The angle at which the roadway meets the railroad tracks may also affect the driver's ability to see an oncoming train. The following accident illustrates this problem.

About 1:10 p.m. on Thursday, May 30, 1996, a northbound Pontiac Grand Am struck a westbound Consolidated Rail Corporation (Conrail) freight train traveling about 48 mph at a passive grade crossing near Montrose, Illinois (case 37). The speed limit along the road was 55 mph. The driver, who was transporting her 3-year-old child, stated that she slowed her vehicle when approaching the crossing, but she did not hear or see the train until just before impact. There were no injuries associated with this accident, but the vehicle was destroyed. Although there were no obstacles in the sight triangle for the approaching motorist, the highway met the railroad tracks at an angle of 35°; thus, the train approached essentially from behind the highway vehicle.

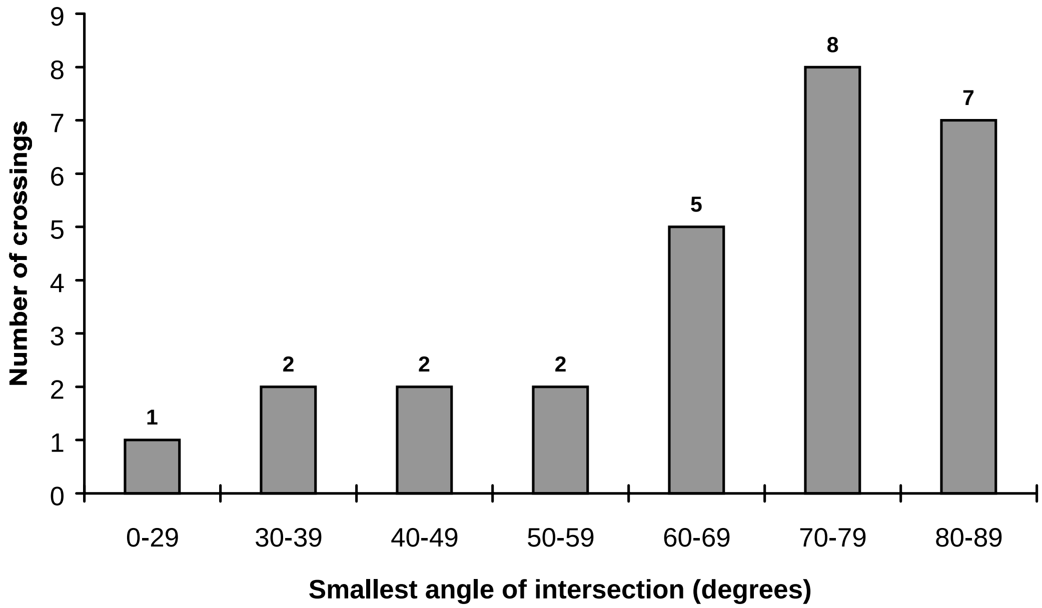

Figure 4–7. Smallest angle of intersection between the railroad tracks and roadway for the 27 study accident crossings with intersections that did not meet at 90°.

According to AASHTO guidelines, "[r]egardless of the type of intersection, for safety and economy, intersecting roads should generally meet at or nearly at right angles." AASHTO recommends that when there is an acute angle of intersection, the road be realigned so that the angle of intersection can be more nearly 90°.[101] The distance a highway vehicle must traverse in order to clear the intersection is greater when the angle is skewed, and therefore the time it takes to safely cross is greater. Trucks are particularly at risk in such a situation because elements of the truck cab environment can further obscure the truckdriver's view of the train.

The Safety Board examined the angle of intersection to the right of the roadway on the side of the crossing from which each accident-involved vehicle approached.[102] For 27 of the 60 study accident grade crossings (45 percent), the roadway did not meet the tracks at right angles (figure 4–7). The Board's study cases suggest that when the angle of intersection deviates from 90°, safety may be compromised.

[101] AASHTO (1990, page 686).

[102] For consistency, the Safety Board selected the angle on the right side of the intersection, although measurements taken from the left side would also have provided sufficient information.

Roadway or Track Curvature

Roadway or track curvature can also affect a driver's ability to see an oncoming train. Twenty-five of the 60 crossings in the Board's sample had track and/or roadway curvature: 9 sets of tracks were curved within the vicinity of the crossing, 13 of the roadways had curves on the sections leading to the crossing, and 3 crossings had curves on both the railroad tracks and the highway. There is no nationwide information on roadway or track curvature for comparison, thus it is impossible to determine whether or not the study sample contains an inordinately high number of crossings with nearby curves in either the highway or the tracks.

AASHTO guidelines state that "to the extent possible, crossings should not be located on either highway or railroad curves."[103] Research into human perception shows that when a driver's trajectory includes a curve, the task of determining the speed and distance of another vehicle is much more difficult. Further, the highway vehicle driver may be distracted by the effort to correctly negotiate the curve.[104] Curves on the railroad tracks can obstruct a driver's view of the train, both on the approach to the crossing and while stopped at the crossing. In addition, AASHTO states that crossings where both the highway and the railroad tracks are curved provide "poor rideability for highway traffic due to conflicting superelevations."[105] This poor ride may cause a driver to concentrate on controlling the highway vehicle rather than looking for trains. Thus, on roads where either the roadway or tracks, or both, have a curve on the approach to the crossing, the highway vehicle driver may fail to recognize the hazards presented by the crossing until it is too late.

[103] AASHTO (1990, page 842).

[104] Berthelon, C. 1993. Curvilinear approach to an intersection and visual detection of a collision. Human Factors 35(3): 521–534 (page 522).

[105] (a) AASHTO (1990, page 842). (b) Superelevation is the technical term describing the angle at which a roadway is banked to enable a vehicle to operate smoothly around a curve at the design speed.

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Chapter 5

Driver Awareness of the Presence of a Grade Crossing and an Oncoming Train

A driver's attention at a crossing can be affected by what that individual expects to see and by distractions inside and outside the vehicle.

Seventeen of the highway vehicle drivers in the Safety Board's study cases stated that they regularly drove over the crossing at which the accident occurred: 6 crossed on a daily basis, 6 crossed each week, and 5 crossed each month.[106] Sixteen of the 18 drivers interviewed by the Safety Board investigators claimed to be aware of the presence of the crossing on the day of the accident. Eight drivers reported they were aware of the train, and six of these eight declared that they were actively looking for a train. One driver reported that although he was looking for a train, he was not aware of the train prior to impact.

Despite their awareness of the crossing, 10 drivers did not detect the oncoming train. For example, on August 12, 1996, a freight train struck a Mack trash truck at a crossing near Bennettsville, South Carolina (case 57). Sight distance at this crossing was unrestricted, and according to the traincrew, the engineer was sounding the train horn and the locomotive headlights were on.[107] The roadway was equipped with an advance warning sign, crossbuck sign, and full pavement markings in good condition. The truckdriver, who sustained minor injuries, stated that he noticed no sources of distraction inside or outside his truck. He also indicated that he drove over this crossing daily and estimated that less than one train a day, on average, used the crossing. The actual number of trains using the crossing daily was two. The driver reported that he did not look for a train on the day of the accident.

[106] As noted in chapter 3, the Safety Board is aware that self-reporting may not be entirely reliable.

[107] At the time of the accident, the locomotive was not equipped, nor was it required to be equipped, with auxiliary alerting lights.

Driver Expectations

Driver attention at railroad crossings has been measured indirectly by watching drivers' head movements as they approach the crossing. An Australian study on human factors in grade crossing accidents shows that drivers' looking behavior, as determined by observable head movements, is far from optimal at grade crossings, with only about 30 percent of the drivers approaching a passive or active crossing conducting a search for a train.[108] Not only did very few of the drivers in that study look, but many of those that did look waited until just before the crossing, and some were still looking as their vehicles went over the crossing.

One factor that can affect whether a driver looks for a train is the driver's expectation of seeing a train. Overall, each of the 18 drivers interviewed by the Safety Board underestimated the frequency of train crossings per day, typically by a factor of 2 to 3 (table 5–1). This low estimate suggests that drivers do not expect trains and thus may not look for trains at a crossing. Further, many train movements are unscheduled and would not be known even to drivers who are familiar with the crossing and with scheduled train traffic.

The driver's perception that a train is not likely to be at the crossing is reinforced each time that driver passes the crossing without seeing a train. Researchers have reported that a driver's response to a potential hazard is a function of both the perceived probability of the adverse event occurring and of the driver's understanding of the severity of the consequence of the event.[109] A person's perception of the probability of a given event is strongly influenced by past experience,[110] and the frequency with which the driver encounters a train at a crossing will influence the likelihood of that driver stopping.

Personal circumstances also cause a driver to associate certain costs with the outcome of a decision to stop or not to stop. Stopping might make the driver late or result in a collision with the highway vehicle behind; conversely, not stopping might result in an accident with a train. Research in signal detection theory has shown that because the

[108] Wigglesworth, E.C. [Royal Australasian College of Surgeons, Melbourne]. 1976. Report on human factors in road-rail crossing accidents. Melbourne, Victoria, Australia: Ministry of Transport. [Inclusive pages not known] (page 83).

[109] Schoppert, D.W.; Hoyt, D.W. 1968. Factors influencing safety at highway-rail grade crossings. National Cooperative Highway Research Program Report 50. Washington, DC: National Academy of Sciences; National Academy of Engineering. 113 p. (page 96).

[110] Schoppert and Hoyt (1968, page 97).

Table 5–1. Number of trains passing through 18 of the study accident crossings per day and number estimated by the highway vehicle driver involved in the accident at the crossing.[a]

Frequency of grade crossing use by accident-involved driver and case number	Driver-estimated number of trains per day	Actual number of trains per day
Daily:		
09	3–6	17
26	3–6	11
40	3–6	7
56	1–2	24
57	<1	2
58	1–2	15
Weekly:		
08	1–2	6
15	7–10	36
27	Unknown	18
37	1–2	15
38	1–2	6
54	7–10	24
Monthly:		
25	1–2	4
28	Unknown	18
48	Unknown	3
52	3–6	11
55	1–2	4
Rarely:		
22	1–2	4

[a] The remaining 42 drivers were not available to the investigators for interview.

frequency of trains at grade crossings is so low, drivers tend to bias their behavior toward not stopping.[111] The FRA has used signal detection theory models to predict which crossings are likely to have accidents and has found that a low train frequency at crossings is associated with a higher rate of accidents.

[111] Raslear, Thomas. 1996. Driver behavior at rail-highway grade crossings: A signal detection theory analysis. In: Safety of highway-railroad grade crossings: research needs workshop. Vol. II: Appendices. DOT/FRA/ORD-95/14.2; DOT-VNTSC-FRA-95-12.2. Washington, DC: U.S. Department of Transportation, Federal Railroad Administration: F-9 through F-56 (page F-22). [Workshop held at and in conjunction with Volpe National Transportation Systems Center, Cambridge, MA.]

Driver Perception of Train Speed and Distance

Even when a driver looks for a train, it may be difficult to accurately gauge the speed and arrival time of an approaching train. Once the train is detected, a driver must decide whether it is safe to proceed across the tracks and then take appropriate action. Guiding this decision will be the driver's perceptual judgments of train velocity and distance. The difficulty of making this judgment is illustrated by the following accidents.

About 10:40 p.m. on August 12, 1996, in Columbus, Ohio, a truckdriver was hauling trash to a nearby lot (case 58). As he approached a private passive crossing, he observed a Conrail train that appeared to be standing still near the crossing. According to the Conrail police department incident report, the locomotive headlight was illuminated; auxiliary lighting use is unknown. According to the traincrew, the train horn was not sounded prior to the accident. As the truckdriver reached the crossing, he realized the train was moving. His realization came too late to avoid the collision.

On March 20, 1996, a tanker truckdriver was leaving a company lot in Clairton, Pennsylvania, heading toward a two-track crossing (case 15). As he approached the crossing, he had an unobstructed view of the tracks. Looking down the tracks, he saw a Conrail freight train in the distance and decided it was safe to cross. According to the locomotive event recorder, the train horn was sounded prior to the accident; according to the traincrew, the locomotive headlight was illuminated. However, the driver misjudged how fast the train was moving, and as the truck crossed the tracks, it was struck by the freight train.

Moving with traffic, merging into traffic, and turning left or right in front of traffic are daily tasks that require a driver to judge the speed and distance of other highway vehicles. Similarly, a driver must judge the speed and distance of an oncoming train to gauge the train's arrival at a grade crossing. However, visual illusions can interfere with the driver's perception of train velocity and distance. For example, an illusion of perspective can mislead a driver about the train's distance:

> Viewed from the crossing, railroad tracks produce the illusion of a great distance. That is because the parallel lines of the rails converge toward the horizon. (It is the same illusion used in art classes to create perspective.) The apparent convergence of the rails give the impression that the train is farther from the crossing than it is.[112]

[112] Operation Lifesaver, Inc. 1997. School bus driver presentation. In: Operation Lifesaver Presenter Guide. Alexandria, VA. [Section 7, page 15].

Research describes illusions regarding train size that can mislead a motorist about the train's velocity.[113] First, the larger an object, the more slowly it appears to be moving; thus, because the train locomotive is a large object, it may appear to be moving more slowly than it is, causing the driver to overestimate the amount of time available to safely clear the crossing. Second, when a car and train are approaching each other at constant speeds, or when a vehicle is stopped at a crossing and looking down the tracks, the principal perceptual cue available to the driver is the rate of growth of the train's apparent size in the visual field. This apparent rate of growth is not linear but hyperbolic. When the train is at a distance, the apparent rate of growth for the object is slow, thereby giving the impression of slow speed. However, as the train gets closer, the increase in the size of the object in the visual field accelerates (figure 5–1). For example, a 10-foot-wide by 15-foot-tall locomotive will occupy a visual angle of 0.43° when it is 2,000 feet from the observer. As the train reaches 1,000 feet, the locomotive's visual angle has doubled to 0.86°. When the train is even closer to the observer, the visual angle also doubles even though the train traverses less distance: the visual angle grows from 3.43° to 6.84° when the train travels from 250 feet to 125 feet from the observer. Drivers tend to be effective at estimating the speed of the train when it is closest because the change in visual angle is rapid. However, drivers tend to decide on the safety of proceeding across the tracks when the train is at greater distances, when the change in visual angle is slow and they are more likely to underestimate the train's speed.

Night also adds to the difficulty in perceiving train speed and distance. Drivers can determine train speed by comparing the train movement with that of the background. However, at night the background is not visible and drivers lose this important cue. The driver in case 58, described previously, who believed a slow moving train was standing still was observing the train at night.

Driver Distractions

Objects or events both inside and outside a vehicle can provide competing stimuli or distractions that reduce driver attentiveness to the task of looking for a train. For example, as the driver in case 37 approached a passive crossing, she was reaching into the back seat to get some food for her child. Prior to entering the crossing, she looked up, saw a train, and hit the brakes. The driver was unable to stop the vehicle before striking the train.

[113] Liebowitz, H.W. 1985. Grade crossing accidents and human factors engineering. American Scientist 73: 558-562.

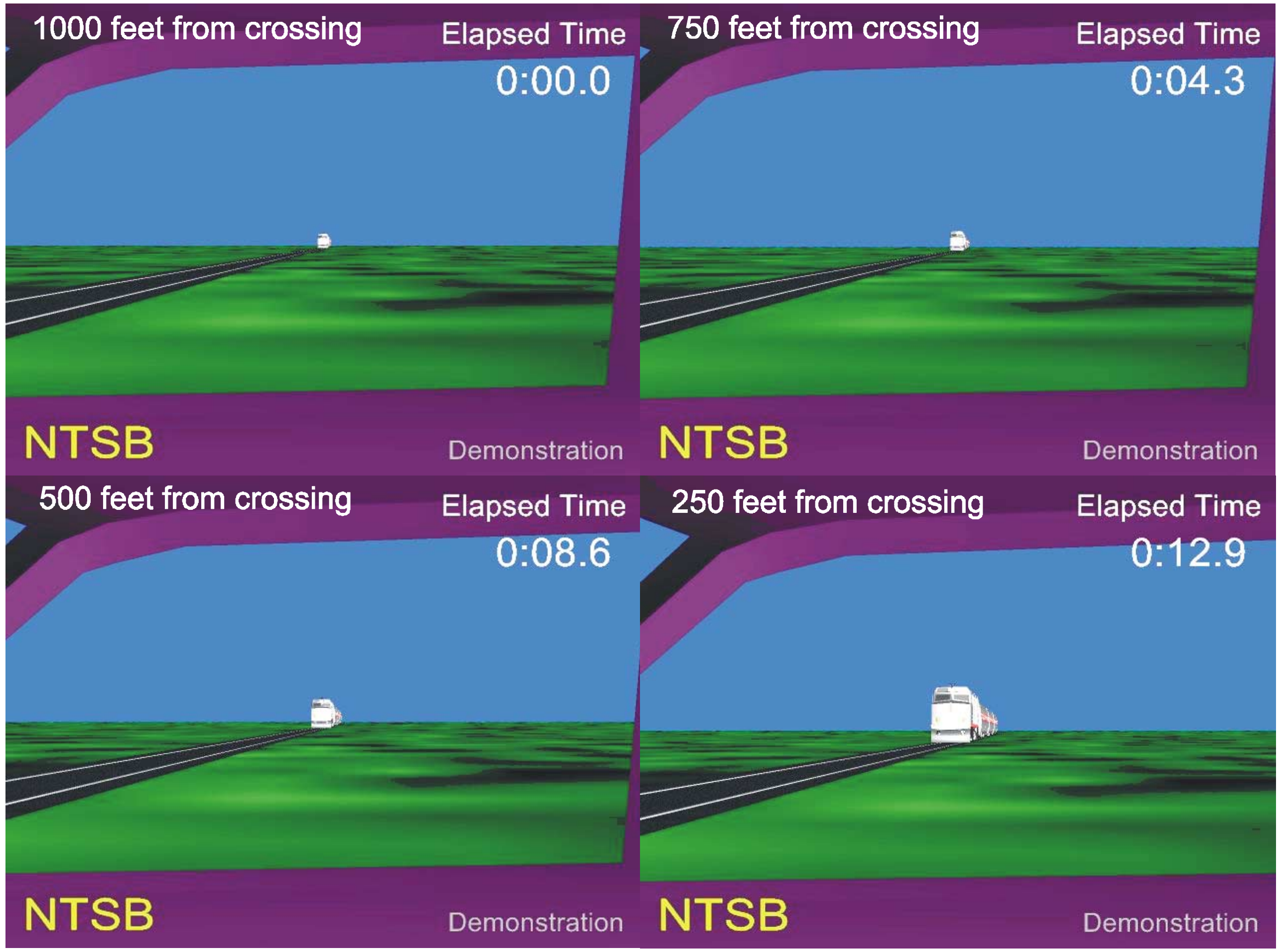

Figure 5–1. Illustration of the apparent change in object size as a train approaches a crossing, as seen by a motorist stopped at the crossing. The train is traveling at 40 mph. (These images were taken from a computer simulation produced by the National Transportation Safety Board, available on the Web at http://www.ntsb.gov/events/gradxing/default.htm.)

Of the 18 interviewed drivers, 8 indicated they had been distracted by at least one source.[114] Stereo systems and passengers were the internal sources of distraction most frequently cited by these drivers; highway traffic was the external source most frequently identified (table 5–2). Two other drivers indicated that they might have been distracted, but they could not identify the source of distraction. The Safety Board cited distraction as the primary probable cause or contributing factor in 12 of the 60 study accidents (shown earlier in chapter 3, table 3–3): 2 nonfatal accidents, and 10 fatal accidents.

Passengers, particularly passenger conversation, was a common source of distraction. Three interviewed drivers stated that they were talking with passengers in their vehicles at the time of the accident, and in a fourth instance (case 6), witnesses stated they saw the driver talking with his passenger (both the driver and the passenger in the highway vehicle were fatally injured in the accident). Research indicates that passenger distraction accounts for the second biggest source of distraction in accidents; objects in the vehicle is the biggest source.[115]

Another source of driver distraction was highway traffic. Three interviewed drivers were distracted by oncoming traffic, and in two of the fatal accidents (cases 41 and 50), distraction attributed to highway traffic was cited in the accident's probable cause. In two of the study accidents, the drivers apparently were preoccupied with vehicles directly in front of them: the fatally injured driver in case 53 followed closely behind a vehicle that cleared the crossing just before the train arrived, and the fatally injured driver in case 41 stopped his vehicle on the tracks to wait for a vehicle in front of him to clear a nearby highway intersection. Even other drivers' attempts to warn of an oncoming train can distract drivers. In one accident (case 40), a driver was focused on another car flashing its headlights. The driver reported that he believed the flashing headlights indicated an impending speed trap; the driver continued into the path of a train.

Intersecting roads and traffic may also distract a driver from looking for a train. When another road intersects with the driver's roadway just before or after the grade crossing, it may increase the number of decisions the driver must make and distract the driver from looking for a train. Similarly, a driver may also be presented with multiple decisions when encountering a grade crossing immediately after turning off of an intersecting roadway onto a road with a grade crossing.

[114] One of the eight drivers was not in the highway vehicle at the time of the accident: the vehicle had stalled while traversing the tracks and the driver had time to get out before the train arrived.

[115] Tijerina, Louis; Kiger, Steven M.; Rockwell, Thomas H.; Tornow, Carina. 1995. Workload assessment of in-cab text message system and cellular phone use by heavy vehicle drivers on the road. In: Proceedings, 39th annual meeting of the Human Factors and Ergonomic Society, Vol. 2; 1995 October 9-13; San Diego, CA. Santa Monica, CA: Human Factors and Ergonomics Society: 1117-1121.

Table 5–2. Sources of distraction when approaching the grade crossing indicated by 10 of the 60 highway vehicle drivers involved in the study accidents.[a]

Case number	Internal source					External source					
	Stereo	Cellular phone	Passenger	Loose item	Other	Highway traffic	Billboard	Pedestrian	Scenery	Second train	Other
15								Unknown			
22	✔		✔								✔
28						✔					
37[b]			✔								
38[b]					✔	✔					
40						✔					
48[c]	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
54[d]	✔										
55	✔										
56	Unknown		✔	✔	Unknown						

[a] Safety Board investigators interviewed 18 of the 60 drivers; 8 of the 18 indicated no distractions on their approach to the grade crossing. The remaining 42 drivers were not available to the investigators for interview.

[b] Distraction was cited as the primary probable cause or contributing factor in the accident.

[c] The highway vehicle had become lodged on the crossing; the driver was away to get assistance when the train arrived and struck the vehicle.

[d] The highway vehicle had stalled while traversing the tracks; the driver had time to get out of the vehicle before the train arrived.

In the afternoon of June 21, 1996, the driver of a Buick Park Avenue approached a grade crossing in Pickerington, Ohio (case 41). About 22 feet beyond the tracks was an intersection with another city street. A car traveling in the same direction as the Buick had just crossed the tracks and was stopped at the intersection. According to witnesses, the driver of the Buick, who appeared to be using a cellular phone, was stopped on the tracks waiting for the vehicle in front of him to clear the intersection. While stopped, the Buick was struck by an arriving Conrail freight train, and the driver was killed.

For the purposes of this study, the Safety Board defined a nearby intersection to be one that lay within 75 feet of the crossing.[116] Twenty-nine of the grade crossings in the study cases had nearby highway intersections: on the far side of the crossing in 12 of the study cases, on the side of the crossing from which the accident-involved highway driver approached in 13 cases, and on both sides of the crossing in 4 cases.

A nearby highway intersection may present a distraction to the driver simply because the driver is aware of it. If a highway intersection on the departure side of the crossing is visible to an approaching driver, the driver's attention may be drawn toward that intersection and away from the crossing. This may be particularly hazardous in urban areas, where the driver's concern for traffic at the upcoming intersection may result in stopping directly on the tracks, as was the case in Pickerington, Ohio. In other situations, the driver of a vehicle turning off a parallel roadway may come upon the crossing before being able to direct attention away from negotiating the turn; at four study crossings, the highway intersection was less than 25 feet from the crossing (cases 1, 15, 44, and 58). In addition, if a train comes from the same direction as a highway vehicle on the parallel roadway, it will come from behind the vehicle, and a driver turning onto the road with the grade crossing may have few moments to react.

The presence of nearby intersections increases the risk at passive crossings. In the Australian study, it was discovered that at a crossing with a nearby intersection, "driver head movements and [train] search at Stanhope [the location of the crossing] were directed firstly at determining the presence of other road users and secondly at assessing the possible development of conflict situations."[117] The drivers observed in that study were more concerned with the dangers presented by other highway traffic and considered the grade crossing only secondarily.

[116] The measurement of 75 feet is not intended to indicate an absolute boundary. Intersections farther from (or closer to) a crossing than 75 feet may still present the opportunity for driver distraction. The FRA inventory database indicates the presence of nearby highway intersections within 75 feet of the crossing; therefore, the Safety Board selected a cutoff point of 75 feet to facilitate comparison between the study data and data in the FRA inventory database.

[117] Wigglesworth (1976, page 80).

Because nearby intersections could present problems for motorists at passive grade crossings, the Safety Board examined the FRA databases to determine how common nearby intersections are. Of the study accident crossings, 46.7 percent (28 of the 60) qualify as having a nearby intersection on either the approach or the departure side of the crossing, whereas 37.7 percent of all public passive crossings have such nearby intersections. The higher percentage of grade crossings with nearby intersections in the study sample than in the FRA inventory database suggests that nearby intersections may be a factor associated with passive grade crossing accidents.

Audibility of the Train Horn

The train horn, and certain auxiliary locomotive lights, are currently the only active signals given to a driver at a passive grade crossing to alert the driver that a train is present. The sound of a train horn is effective as a warning only if the driver recognizes it as a train horn; this recognition is affected by the interior vehicle noise levels, exterior traffic noise, the sound characteristics of the train horn, driver expectations, and insertion loss.[118]

Although the horn was sounded in 14 of the accidents in which the driver survived and was interviewed by Safety Board investigators, only 4 drivers reported hearing the horn; 2 of the 4 drivers were already outside of their vehicles. A 1986 Safety Board study of 75 collisions between passenger/commuter trains and motor vehicles at grade crossings found that in 27 cases the train's audible warning system was ineffective because of either high ambient interior noise levels of the vehicle or noise levels caused by vehicle engines.[119] The fact that the occupants of the vehicles could not hear the audible warning system of the train indicated that the existing audible warning system was inadequate as a primary warning system. In this 1986 study, the Safety Board concluded that train horns should be improved to better address the audibility concern, and accordingly issued Safety Recommendation R-86-45 to the FRA.[120]

[118] Insertion loss is the difference between the measured values of a sound from an exterior sound source taken outside the highway vehicle and inside the vehicle.

[119] National Transportation Safety Board. 1986. Passenger/commuter train and motor vehicle collisions at grade crossings (1985). Safety Study NTSB/SS-86/04. Washington, DC. 210 p.

[120] Safety Recommendation R-86-45 was classified "Closed—Reconsidered" on September 4, 1990. At that time, the FRA indicated that changing the sound characteristics of the train horn was very difficult to justify, and increasing the volume was not acceptable. However, the FRA Office of Research and Development now reports that it has studies underway on optimal sound characteristics of audible warning devices and the adequacy of audible warning systems.

The FRA's regulation for audible warning devices states that " . . . each locomotive shall be provided with an audible warning device that produces a minimum sound level of 96 dB(A)[121] at 100 feet forward of the locomotive in its direction of travel" (Paragraph 229.129a in 49 CFR Part 229). According to research by an audiologist, detecting the presence of a sound will not lead to appropriate action unless the sound is identified or has reached the alerting level.[122] For a sound to be identified, the warning signal must be 3 to 8 dB above the threshold of detection;[123] to reach the alerting level, a warning signal must be about 10 dB above the ambient noise level such that the sound is attention-getting.[124] Different characteristics of the terrain surrounding a grade crossing can affect the transmission of sound: acoustically hard surfaces can reflect the sound; other surfaces can absorb sound waves. There may be crossings where the presence of buildings and other landscape elements can block the sound of a train horn completely. If a sound is not reflected or interrupted, its intensity drops 6 dB with each doubling of distance.[125]

Additional audibility problems occur when the sound from a train horn must penetrate the outer body of a vehicle. The Safety Board's investigation of the 1995 collision between a school bus and a train in Fox River Grove, Illinois, found that the train horn and grade crossing bell did not provide a warning sufficient to overcome the effects of sound attenuation material installed in the bus.[126] Supplementary investigation by the Safety Board for this study on passive grade crossing safety indicates that for drivers of some highway vehicles on the road today, the sound of a train horn 100 feet away is not sufficient to penetrate the vehicle shell and to alert them to the presence of a train (appendix F). In addition to warning a driver of the presence of an oncoming train, the horn alerts the driver of the direction from which the train is coming. If a window is

[121] A decibel is a logarithmic unit that is used to compare one value with a reference value. When used to describe sound levels, a reading of 0 decibels indicates the threshold of hearing of a young person with normal hearing, and a reading of 120 decibels is the threshold of feeling sound vibrations. These limits can vary depending on the person. There are different scales by which to measure sound levels; "(A)" denotes the scale by which human hearing is measured. As used in this report, the levels are assumed to be measured by this scale.

[122] (a) Lipscomb, David M. 1982. Audibility and the law. In: Kramer, M.B.; Armbruster, J.M., eds. Forensic Audiology. Baltimore, MD: University Park Press: 191-222. [Chapter 11.] (b) The "alerting level" is the sound level at which a person is aware of a sound and recognizes the source.

[123] The "threshold of detection" is the sound level at which a person is aware of a sound.

[124] Skeiber, Stanley C.; Mason, Robert L.; Potter, R.C. 1978. Effectiveness of audible warning devices on emergency vehicles. Sound and Vibration. February: 14-22.

[125] Acoustical Society of America. 1994. Procedures for outdoor measurement of sound pressure level. American National Standard ANSI S12.18-1994. New York, NY: American National Standards Institute. 18 p. (page 4).

[126] (a) Highway Accident Report NTSB/HAR-96/02. (b) The sound levels at the busdriver's position were measured by the Safety Board when the horn from the cab control car was sounded at distances ranging from the impact point to about 2,500 feet away. The train horn, at 100 feet from impact, was only 3–5 decibels above the ambient noise level within the school bus. The train's horn exceeded the ambient noise levels at the driver's location only when it was located less than 100 feet from impact.

partially open on the side of the vehicle opposite from the direction of the approaching train, a driver may be misdirected and believe that the train is coming from the direction of the open window.[127]

At the Safety Board's public forum, an audiologist testified that "more emphasis than is presently being given, [should] be given to the fact—not the idea, but the fact—that horns are not and cannot be audible under many circumstances."[128] With automobile manufacturers fabricating vehicles with enhanced sound attenuation qualities and communities promoting the reduction of train horn noise levels, the options available to improve grade crossing safety using train-mounted audible warning devices are limited. Safety Board testing shows that with the interior noise levels produced in everyday driving, in addition to the improved sound attenuation in today's highway vehicles, it is difficult for a driver to detect the presence of a train by its audible warning only and still have sufficient time to react to its presence. There are circumstances under which the horn can be heard, but there is a tradeoff between a sound traveling an optimal distance and the ability to overcome ambient noise.

In 1990, the FRA published the results of a study that examined the accident experience at Florida East Coast Railway Company and CSX grade crossings affected by Florida's bans on the use of train horns.[129] The FRA subsequently published the results of a study examining the same issue on a nationwide basis; this study indicates that at crossings where horn bans were instituted (more than 2,000 crossings), the occurrence of accidents increased.[130] In 1995, Transport Canada also published the results of a study about the effect on safety of the use of train horn bans at about 400 crossings in Canada.[131] All three of these studies indicated that completely eliminating the use of train horns at grade crossings adversely affects safety. The Safety Board's study shows, however, that the train horn often provides an ineffective warning, even when drivers have their vehicle windows open.

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[127] Lipscomb, David M. 1995. Auditory perceptual factors influencing the audibility of train horns. In: Proceedings, 3rd international symposium on railroad-highway grade crossing research and safety; 1994 October 24-26; Knoxville, TN. Knoxville: University of Tennessee: 193-202.

[128] Statement by a consulting audiologist, formerly a professor of audiology and speech pathologist at the University of Tennessee. In: Transcript of the NTSB public forum on safety at passive grade crossings (page 199).

[129] U.S. Department of Transportation, Federal Railroad Administration, Office of Safety. 1990. Florida's train whistle ban. Washington, DC. 11 p., plus appendixes.

[130] U.S. Department of Transportation, Federal Railroad Administration. 1995. Nationwide study of train whistle bans. Washington DC. 56 p.

[131] Transport Canada, Railway Safety Branch. 1995. The effect on safety of eliminating whistling at railway grade crossings. TP 12682. Ottawa, Ontario, Canada: Transport Canada, Railway Safety Branch. 42 p., plus appendixes. [Study conducted by Sypher:Mueller International, Inc., Ottawa, Ontario.]

The Volpe Center is currently conducting research that involves enhanced train-mounted and wayside-mounted warning devices in an attempt to reduce the impact of train noise in communities.[132] Instead of blowing the horn mounted on the train, a stationary horn mounted at the crossing and directed toward approaching highway traffic would be activated when the train approaches the grade crossing. Residents in the path of the horn might receive a greater exposure to the noise, but those not directly in the path would receive less exposure than from conventional train-mounted horns. Preliminary results indicate that train engineers did not trust the wayside horn to work and were still using the conventional train-mounted horns.[133] Final results, including responses from the local residents, are expected to be published in late summer of 1998. The Safety Board looks forward to reviewing the results of the study and will monitor any subsequent action taken by the FRA and/or the railroads to implement wayside train horn systems.

[132] Multer, Jordan. 1995. Field study of a wayside auditory warning for motorists. In: Proceedings, 3rd international symposium on railroad-highway grade crossing research and safety; 1994 October 24-26; Knoxville, TN. Knoxville: University of Tennessee: 203-215.

[133] Multer (1995).

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Chapter 6

Discussion: Measures To Improve Safety at Passive Grade Crossings

In 1996, passive crossings accounted for about three-quarters of all grade crossings in the United States; although there is less highway and train traffic at passive crossings than at active crossings, passive crossings accounted for 54 percent of all grade crossing accidents and 60 percent of all grade crossing fatalities in that year.

Detecting a train at a passive crossing and making the correct decisions about whether a highway vehicle should stop at the crossing or can cross the tracks safely before the train arrives is a complex task that has confronted the Nation's motoring public for decades. The task is affected by the driver's ability to (1) detect the presence of the crossing, (2) detect the presence of a train, and (3) accurately gauge the train's speed and arrival time at the crossing. The task is further complicated by the driver's attention at a crossing, which, as previously discussed, can be affected by what that individual expects to see. The Safety Board concludes that a driver's decision to look for a train may be adversely affected by the driver's familiarity with and expectations at a specific passive grade crossing and the driver's experience with passive crossings in general. Also, as previously discussed, the train horn—one of only two active signals given to a driver to alert the driver that a train is present—is effective as a warning only if the driver recognizes it as a train horn. The Safety Board therefore concludes that in some circumstances, audible warning devices on trains fail to meet their objective of alerting motorists to an oncoming train because of highway vehicle design and environmental factors.

Despite the complexity of the task to detect the presence of a train at a passive crossing, the approach to passive grade crossing safety has remained relatively unchanged over the years. The current approach includes providing a sight distance triangle for an approaching motorist to see a train and installing a railroad crossing advance warning sign, pavement markings, and a crossbuck sign, where appropriate. As the accident sample in the Safety Board's study illustrates, this approach has been inadequate in many instances.

More than half of the crossings in the Safety Board's sample (33 of 60) had conditions that limited the driver's ability to see an oncoming train. Only 6 of the 33 crossings had permanent structures (for example, buildings or hills) within the sight triangle. In the cases where the sight obstructions were caused by vegetation (for example, trees, brush, crops, or weeds), the vegetation was often on the roadway or the railroad rights-of-way, where it likely could and should have been cleared. The Board notes, however, that it does not have the detailed information necessary to determine whether the vegetation at each of these crossings was on the roadway as opposed to the railroad rights-of-way, or whether the vegetation was on private property. The Board is aware that it may not be possible to remove sight obstructions that occur on private property adjacent to the crossing. The FHWA also acknowledges that it is not always possible to clear the sight triangle, and recommends in such cases consideration of changes to the roadway that would alter the size of the necessary sight triangle, such as speed limit reductions or the installation of active warning devices.[134]

Witnesses at the Safety Board's public forum indicate that problems with sight distances at passive crossings are not limited to the crossings in the study sample. The University of Florida transportation engineering coordinator performed a review of every crossing in a particular county in Mississippi. According to the coordinator's calculations, because of sight restrictions, about half of the crossings were safe only if the train traveled no faster than 25 mph. He stated that, according to the railroad involved, the crossings in that county were representative of that railroad's crossings in other States in which it operates.[135] Kansas State University performed a similar survey of crossings in Kansas. Of the 50 randomly selected crossings that were examined, 35 percent offered limited sight distance to a motorist approaching the crossing, and 50 percent had limited sight distance available to a motorist stopped at the crossing.[136]

In addition to problems with sight distances, the information being communicated by railroad crossing advance warning signs, crossbuck signs, and multiple track signs is not clear according to the responses of the 18 interviewed drivers in the Safety Board's sample. Currently, the advance warning signs do not communicate whether the crossing ahead is active or passive, thus drivers may not understand the level of attention required for the crossing just ahead, nor may the drivers understand that they need to start looking for a train when or before they reach the position of the advance warning sign. The Safety Board concludes that the action a driver needs to take at a passive grade crossing should be communicated to the driver at the point of the advance warning sign.

Further, there is no uniformity of signage at passive crossings, and no one sign informs the driver that the crossing is passive. According to a witness at the Safety Board's public forum, the highway engineering approach to signs at passive grade crossings has

[134] U.S. Department of Transportation, Federal Highway Administration. 1986. Railroad-highway grade crossing handbook. 2nd ed. FHWA-TS-86-215. Washington, DC. 261 p. (page 135).

[135] Statement by the University of Florida transportation engineering coordinator. In: Transcript of the NTSB public forum on safety at passive grade crossings (page 175).

[136] Remarks by the Director, Center for Transportation Research and Training, Kansas State University. In: Transcript of the NTSB public forum on safety at passive grade crossings (page 186).

hardly changed in more than half a century; in that time "our drivers have changed, our vehicles have changed, other parts of the driving environment have all changed, yet our approach to traffic control, warning and alerting drivers has changed almost none."[137] This witness concluded that "we need to incorporate and integrate traffic control systems at passive crossings which give specific warnings about specific hazards."

A 1994 study by Texas A & M University examined the effect of communicating driver responsibilities on the grade crossing signs.[138] The study examined the looking behavior of drivers at crossings with only a crossbuck sign and at crossings that included either a "yield to train" or a "look for train" sign. The study found a significant increase in looking behavior for both signs that indicated and communicated the driver action needed.

The FHWA measured driver understanding of the appropriate action to take upon seeing a crossbuck sign compared to several experimental passive signs, including a "yield to train" variant.[139] The "yield to train" sign elicited the most correct responses to what action the sign required; the standard crossbuck resulted in significantly more incorrect responses regarding the understanding of driver actions required.

In 1993, the FRA sponsored a project that examined technologies and practices used in (1) signaling the approach of a train and detecting trains at active grade crossings, (2) detecting grade crossing obstructions, (3) grade crossing warning devices and barrier systems, and (4) determining the appropriate warning devices for grade crossings. For this project, researchers from the Volpe Center and Battelle compared the practices of the United States, Canada, the United Kingdom, France, Spain, Italy, Germany, and Sweden. According to Volpe Center researchers, the results are being drafted and will be released in late fall of 1998.

In September 1997, the FHWA sponsored a technology assessment visit to five countries in Europe (Denmark, the Netherlands, Germany, Italy, and Spain) to survey their grade crossing safety practices. According to a preliminary report, "warning signs on highway approaches to crossings vary somewhat from country to country, but generally include an advance warning sign which indicates the type of crossing ahead (passive

[137] Statement by an official of the University of Tennessee Transportation Center. In: Transcript of the NTSB public forum on safety at passive grade crossings (page 205).

[138] Presentation by the study manager to Safety Board staff at a session held in Knoxville, Tennessee; January 23-26, 1996.

[139] U.S. Department of Transportation, Federal Highway Administration. 1993. A preliminary laboratory investigation of passive railroad crossing signs. FHWA-RD-93-153. Washington, DC. 22 p.

or active).”[140] In Denmark, for example, advance warning signs at passive crossings advise the motorist to look both ways, and the approach speed limit is 30 kilometers per hour (about 19 mph).[141]

The data from the Safety Board’s study, testimony at the Safety Board’s public forum, and the research cited above indicate that the current set of traffic signs used at passive crossings is not adequate.

To eliminate the continuing problems encountered by the motoring public at passive crossings, the Safety Board concludes that a systematic and hierarchic approach to improving passive grade crossing safety is needed, an approach that does not depend primarily on the ability of the driver approaching the crossing to see an oncoming train. The hierarchic approach includes grade separation and closure, installation of active warning devices, improved signage, and intelligent transportation systems technology. The approach includes immediate and long-term measures.

Grade Separation, Crossing Closure, and Installation of Train-Activated Warning Devices

Consolidation (the separation and closure) of passive crossings is the most effective means to eliminate accidents between highway vehicles and trains. As discussed earlier in this report, in 1991, the Administrator of the FRA established a safety goal to reduce the nearly 293,000 grade crossings (public and private, active and passive) by 25 percent by the year 2001. As of 1996, the FRA reported a decrease of about 27,000 grade crossings, a cumulative reduction of 9.3 percent.[142] Table 6–1 illustrates the extent to which the FRA initiative has succeeded. Although there has been a slight overall decrease in accidents at passive crossings since 1993, given the short timeframe, this decrease cannot be considered statistically significant:

Year	Number of accidents at passive crossings
1993	2,478
1994	2,521
1995	2,373
1996	2,208

[140] U.S. Department of Transportation, Federal Highway Administration. [In preparation.] European highway-rail crossing safety systems and practices: a U.S. DOT pre-scan assessment. 25 p. (page 24). [Draft.]

[141] FHWA (Draft in preparation, page 4).

[142] Since 1992, there has been a cumulative reduction in all passive crossings of 8.4 percent. Although available for public passive crossings, similar data are not available for private passive crossings prior to 1992.

Table 6–1. Reduction in the number of grade crossings through the Federal Railroad Administration initiative on crossing elimination, 1991 through 1996.[(a)]

Year	Number of public and private crossings	Decrease since 1991	Percent reduction since 1991
1990 (baseline)	292,839	—	—
1991	289,519	3,320	1.1
1992	280,585	12,254	4.2
1993	276,468	16,371	5.6
1994	272,750	20,089	6.9
1995	268,676	24,163	8.3
1996	265,721	27,118	9.3

[(a)] The FRA's goal is a 25-percent reduction in the number of crossings by the year 2001. (Carmichael, Gilbert E. 1991. Highway–rail grade crossings: the unfinished safety agenda. In: The job's not done: Proceedings, 1991 national conference on highway–rail safety; 1991 July 7–10; Philadelphia, PA. College Station, TX: TransCom: 5–9.)

Source: U.S. Department of Transportation, Federal Railroad Administration. 1991–1997. Highway–rail crossing accident/incident and inventory bulletin. Nos. 13–19. Washington, DC. Annual.

Representatives at the Safety Board's public forum discussed the difficulties they face when trying to close dangerous and redundant crossings. The representative of one railroad company reported that for every 15 crossing closures initiated by the railroad, only one succeeds because if the public objects, few, if any crossings are closed, regardless of whether the grade crossings are dangerous.[143] The witness from the State of Missouri agreed that compromises on consolidation and closures must be reached between the railroads and the municipal and county officials. In Missouri, a State task force was created in 1993 with representatives from county and municipal government associations, railroads, and State agencies. The representatives of county and municipal government associations inform their constituents (county and municipal engineers, county or municipal governments) of the State's reasons for wanting to consolidate and close crossings, thus making it easier for their constituents to understand the need for these closures and to voice their concerns. Missouri is closing about 15 crossings annually.

The Safety Board strongly supports the FRA Administrator's goal to reduce the number of grade crossings through separation and closure. However, the Safety Board also recognizes that it will not be possible to close all passive grade crossings in the near future; consequently, there is a need to carefully determine through a systematic approach what level of improvement is appropriate for each passive crossing.

[143] Remarks by the manager of grade crossing safety, Norfolk Southern Corporation. In: Transcript of the NTSB public forum on safety at passive grade crossings (pages 315-316).

The Safety Board's study identified several physical characteristics at passive highway–rail grade crossings that appear to contribute to the occurrence of accidents because they make it difficult for the motorist to see a train (inadequate sight distance, roadway–track intersection angles less than 90°, and roadway and track curvature), and/or because they distract the motorist's attention from the task of looking for a train (nearby roadway intersections). The Safety Board concludes that these physical characteristics can affect the level of safety at passive grade crossings. Roadway and/or track conditions, which include all these characteristics, were determined to be the primary probable cause or a contributing factor in 20 of the 60 study accidents.

Although the FHWA Handbook and the AASHTO Greenbook provide guidance to assist highway engineers in the physical and geometric design of safe roadway systems, the characteristics at 54 of the 60 study accident crossings failed to adhere to at least one of these guidelines. The Safety Board concludes that the safety of passive grade crossings is enhanced when their design adheres to the applicable standards and guidelines provided by the FHWA and AASHTO. The Safety Board believes, therefore, that the States should evaluate periodically, or at least every 5 years, all passive grade crossings to determine compliance with existing FHWA and AASHTO guidelines regarding sight distances, angle of intersection where the roadway meets the tracks, curves on the roadway or tracks, and nearby roadway intersections. For those crossings determined not to be in compliance with the guidelines, the States should initiate activity to bring these crossings into compliance, wherever possible. The Safety Board acknowledges that of the four characteristics outlined above, it may be feasible to bring the crossings into compliance only with regard to sight distance. Where passive crossings cannot be brought into compliance for reasons such as permanent obstructions at the stop line, the States should target those crossings for installation of active warning devices, grade separation, or closure.

If separation or closure is not possible, the next most desirable method to improve safety at passive crossings is to equip passive crossings with active devices that warn the motorist of an oncoming train. Section 130 of 23 U.S.C. provides for the allocation of funds to the States for the specific purpose of improving safety at grade crossings. In order for a State to qualify for the funds, it must "conduct and systematically maintain a survey of all highways to identify those railroad crossings which may require separation, relocation, or protective devices, and establish and implement a schedule of projects for this purpose." Since the inception of Section 130 funds in 1973, the FHWA has disbursed more than $3 billion to the States under the auspices of this program.[144] States use various formulas to help them identify the best candidates for closure or upgrade. Most of these formulas use information about the amount of train and highway traffic at a crossing, and some may incorporate information about accident history.

[144] States must annually report to the FHWA the amount of Section 130 money spent on (1) warning devices at grade crossings and (2) all other crossing projects, including grade separations and crossing closures.

A survey of the States conducted by Auburn University in 1994 indicated that more than half of the 41 responding States rely on methods or formulas that do not include information about sight distance, crossing angle, curvature, or nearby intersections.[145] The remainder of the responding States have developed their own formulas, but the survey report did not provide the specifics of these formulas or indicate whether they incorporate data about the physical characteristics of interest. Information from the FRA indicates that among the States with the largest number of passive crossings, some use versions of the formulas that may not address the safety effects of the physical characteristics.[146] States could better identify passive crossings in need of improvements by including information about the characteristics in their formulas. The Safety Board believes, therefore, that the DOT should develop a standardized hazard index or a safety prediction formula that will include all variables proven by research or experience to be useful in evaluating highway–rail grade crossings, and require the States to use it.

State and Federal agencies as well as private entities use the FRA databases to help them assess safety at grade crossings and to establish priority schedules for crossing improvement projects.[147] In April 1995, 75 delegates representing noted researchers from both public agencies and private entities attended a workshop to develop consensus on projected research needs regarding grade crossing safety. One of the topical areas discussed at this workshop was that of data requirements; the delegates expressed the need for research to:

- [i]dentify data requirements for a broad range of safety studies;
- evaluate current data elements and data collection and/or management systems;
- evaluate new data collection, storage, retrieval technologies; and
- develop recommendations for specific data to be collected, how it will be collected and managed, and organizations responsible for these activities.[148]

[145] Bowman, Brian L.; Colson, Cecil. 1994. Current State practices and recommendations for improving rail-highway grade crossing program. In: Traffic signing, signals, and visibility. Transportation Research Record 1456. Washington, DC: Transportation Research Board, National Research Council: 139-145 (page 139).

[146] Telephone conversation with staff of the FRA Office of Safety Analysis on April 17, 1998.

[147] The FRA database system, which includes the Grade Crossing Inventory System (GCIS) and the accident/incident databases, is sometimes used in conjunction with separate databases maintained by the individual States. The GCIS consists of one large file intended to document all public and private grade crossings in the United States. It was created and is maintained through voluntary submissions from both the States and the railroads.

[148] U.S. Department of Transportation, Federal Railroad Administration. 1996. Safety of highway-railroad grade crossings: research needs workshop. Vol. I. DOT/FRA/ORD-95/14.1; DOT-VNTSC-FRA-95-12.1. Washington, DC. Variously paged. [Workshop held at and in conjunction with Volpe National Transportation Systems Center, Cambridge, MA.]

For the inventory database to be useful, it must contain elements that record data on the crossing characteristics determined to affect safety at passive crossings. The Safety Board's study highlights four crossing characteristics that affect safety at passive crossings. Currently, however, the GCIS contains data on only two of the physical characteristics of interest: the crossing angle of intersection, and the presence of nearby roadway intersections. Without data in the GCIS on sight distances and on the presence of curves on the roadway and on the tracks, States may not have adequate information by which to evaluate safety improvements needed at passive crossings. Therefore, the Safety Board believes that the FRA should modify the GCIS to include information on (1) the sight distances available to a motorist, and (2) the presence of curves on the roadway and on the tracks. Further, the FRA should direct the States to include these data as a part of the regularly scheduled updates of the database.

The Safety Board acknowledges that not all passive grade crossings that fail to adhere to the applicable guidelines will be upgraded with active warning devices in the near future. The remainder of this discussion addresses improvements that can be made in the meantime at grade crossings that will remain passive.

Improved Signage

The Safety Board's study suggests the need for a system-wide approach that provides for uniformity of signage at passive crossings and instructs the driver what action is needed while providing the driver adequate time to react accordingly.

Stop Signs

The issue of installing stop signs at highway–rail crossings has been debated for many decades. A 1929 report by the National Association of Railroad and Utilities Commissioners noted the following:

> In many States, experience with the "Stop" law, that is, the law requiring all vehicles on the highway to come to a full stop before passing over any railroad crossing at grade, indicates that enforcement of this requirement is not practical. . . . [However,] . . . in some States, where the stopping of highway traffic is required at certain crossings which are designated "stop crossings" or "extra hazardous crossings," . . . better results are being secured.[149]

A report on highway–rail grade crossing accidents from 1935 to 1954 stated that "unrealistic regulations, such as the requirement that vehicles stop or slow down to 5 mph at the approach to a crossing, are so generally disregarded that they are not effective and create

[149] National Association of Railroad and Utilities Commissioners. 1929. Report of committee on railroad grade crossings, elimination and protection. [Publisher's location not indicated.] 72 p.

disrespect for warnings generally."[150] In 1985, however, the FHWA indicated that upgrading from no stop signs to stop signs at crossings resulted in an overall reduction in the expected number of accidents of 35 percent.[151]

In response to requests for guidance on the selection of highway–rail grade crossings for the installation of stop and yield signs, the FHWA and the FRA in 1993 jointly developed recommended guidance.[152] The document developed by the FHWA and FRA stated "it is recommended that the following considerations be met in every case where a STOP sign is installed:"

1. Local and/or State police and judicial officials will commit to a program of enforcement no less vigorous than would apply at a highway intersection equipped with STOP signs.
2. Installation of a STOP sign would not occasion a more dangerous situation (taking into consideration both the likelihood and severity of highway–rail collisions and other highway traffic risks) than would exist with a YIELD sign.

The document further stated that "any one of the following conditions indicate that use of STOP signs would tend to reduce risk of a highway–rail collision. It is recommended that the following considerations be weighed against the [factors in opposition to STOP signs]:"

1. Maximum train speeds equal or exceed 30 mph (a factor highly correlated with highway–rail accident severity).
2. Highway traffic mix includes buses, hazardous materials carriers and/or large (trash or earth moving) equipment.
3. Train movements are 10 or more per day, 5 or more days per week.
4. The rail line is used by passenger trains.
5. The rail line is regularly used to transport a significant quantity of hazardous materials.

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[150] Interstate Commerce Commission, Bureau of Transport Economics and Statistics. 1955. Rail-highway grade-crossing accidents 1935-1954. Statement 5521; File 4-B-1. Washington, DC. 123 p. (page 60).

[151] U.S. Department of Transportation, Federal Highway Administration. 1985. Effectiveness of motorist warning devices at rail-highway crossings. FHWA/RD-85/015; DOT-TSC-FHWA-85-1. Washington, DC. Variously paged (page 3-16). [Prepared by the Transportation Systems Center, Research and Special Programs Administration.]

[152] U.S. Department of Transportation; Federal Highway Administration; Federal Railroad Administration. 1993. Recommended guidance for stop and yield sign installation at highway-rail grade crossings. Washington, DC. 3 p. [Attachment 2 to a memorandum from the Associate Administrator for Safety and Systems Applications, FHWA, and the Associate Administrator for Safety, FRA, issued on July 8, 1993, to the FHWA Regional Administrators and the FRA Regional Directors of Railroad Safety.]

6. The highway crosses two or more tracks, particularly where both tracks are main tracks or one track is a passing siding that is frequently used.
7. The angle of approach to the crossing is skewed.
8. The line of sight from an approaching highway vehicle to an approaching train is restricted such that approaching traffic is required to substantially reduce speed.

According to the document, “factors to be weighed in opposition to STOP signs,” or “contra-indications,” include the following:

1. The highway is other than secondary in character. Recommended maximum of 400 ADT [average daily traffic] in rural areas, and 1,500 ADT in urban areas.
2. The roadway is a steep ascending grade to or through the crossing, sight distance in both directions is unrestricted in relation to maximum closing speed, and the crossing is used by heavy vehicles.

The Safety Board acknowledges that there has been some concern expressed about the use of stop signs at passive crossings. According to one witness at the Board’s public forum, “stop signs don’t seem to make a difference because people recognize it is a stop sign at a railway crossing, not a stop sign at a road crossing.”[153] Twenty-two accident crossings in the Safety Board’s study were protected by stop signs, but 11 highway vehicle drivers made no effort to stop. The results of the Safety Board study are consistent with previous findings on stop sign compliance at passive crossings. A study funded by the FHWA found that 60 percent of drivers stopped at crossing stop signs compared with 80 percent who stopped at highway intersection stop signs where there was no grade crossing.[154] Another study reported that for familiar crossings, stopping compliance can be as low as 29 percent.[155] A third study indicated that as few as 18 percent of all motorists come to a full stop, even at crossings with no available sight distance.[156] This is

[153] Statement by an official of the Canadian National Railway. In: Transcript of the NTSB public forum on safety at passive grade crossings (page 114).

[154] U.S. Department of Transportation, Federal Highway Administration. 1978. Safety features of stop signs at rail-highway grade crossings. Vol. 1: Executive summary. FHWA-RE-78-40. Washington, DC. 17 p. [Prepared by BioTechnology; Falls Church, VA.]

[155] Parsonson, P.S.; Rinalducci, E.J. 1982. Positive guidance demonstration project at a railroad-highway grade crossing. In: Automotive technology, information needs of highway users, and promotion of safety belt usage. Transportation Research Record 844. Washington DC: Transportation Research Board, National Research Council: 29-34.

[156] Burnham, A. 1995. Stop sign effectiveness at railroad grade crossings (abuse without excuse). In: Proceedings, 3rd international symposium on railroad-highway grade crossing research and safety; 1994 October 24-26; Knoxville, TN. Knoxville: University of Tennessee: 91-113 (page 105).

particularly disconcerting because most of the highway vehicle drivers in the Safety Board's study cases had their accidents at familiar crossings, and many of the crossings had less sight distance for approaching motorists than is recommended by AASHTO.

Another concern raised about stop signs, as described in chapter 5, is that drivers have difficulty judging the speed of an approaching train, even when there is some apparent movement across the visual field, as occurs when a driver some distance away from the crossing sees an approaching train. The cues provided by the lateral movement of the train are not available to the driver who is stopped at the crossing; the only information available to this driver comes from the rate of apparent change in the train's size, which varies according to the distance between the driver and the approaching train.

In addition, drivers of large trucks point out that if they are forced to come to a full stop, it takes several seconds longer to clear a crossing than it does if the truck merely drops down to a slow roll.[157] Federal regulations in 49 CFR 392.10, however, require certain commercial vehicles transporting hazardous materials to stop at all grade crossings, whether or not there is a stop sign present. Further, in its investigations of two collisions involving trains and tank trucks transporting hazardous materials, the Safety Board found that the collisions could have been avoided had the truckdrivers stopped at the crossings.[158]

Despite concerns about the use of stop signs at passive crossings, the Safety Board believes that the benefits of stop signs at passive crossings outweigh the concerns. Foremost, in the Safety Board's opinion, is the need for a system-wide approach that provides consistent information and instruction to the driver. Installation of stop signs at passive crossings accomplishes this objective. Specifically, (1) the action required by a stop sign is well understood by drivers, (2) a driver stopped at a crossing has more time in which to detect an approaching train, and (3) sight distance along the tracks when viewed from a stop line is generally adequate, according to study accident data. In the Board's 60 cases, sight obstructions existed for a driver stopped at the crossing in only 10 cases; in comparison, there were 33 cases in which the visibility was limited on the approach to the crossing. By placing a stop sign at a passive crossing, a clear, unambiguous message is sent to the driver so that the driver knows both where the crossing is and what action must be taken. Further, the presence of a stop ahead sign, required by the MUTCD before a stop sign at a grade crossing, warns the driver in advance of what action is

[157] Remarks by a private-sector investigator of railroad crossing accidents. In: Transcript of the NTSB public forum on safety at passive grade crossings (page 102).

[158] (a) National Transportation Safety Board. 1971. Illinois Central Railroad Company, train No. 1 collision with gasoline tank truck at South Second Street grade crossing; Loda, Illinois; January 24, 1970. Railroad/Highway Accident Report NTSB/RHR-71/1. Washington, DC. 28 p. (b) National Transportation Safety Board. 1989. Consolidated Rail Corporation train collision with Island Transportation Corporation truck; Roosevelt Avenue grade crossing near Lafayette Street; Carteret, New Jersey; December 6, 1988. Railroad/Highway Accident Report NTSB/RHR-89/1. Washington, DC.

needed. Requiring the driver to stop at passive crossings can eliminate some of the problems created by limited sight distance or other physical characteristics such as skewed angle of intersection along the roadway approach.

In the Safety Board's study sample, several conditions existed that were consistent with conditions that would prompt installation of stop signs according to the FHWA and FRA joint guidance, including inadequate sight distance, skewed angle of approach, train traffic exceeding 10 trains per day, and/or maximum train speeds equal to or exceeding 30 mph (table 6–2). Although many of the crossings in the Board's sample met the conditions of the FHWA and FRA guidance that warranted installation of a stop sign, none were installed. For example, in 36 of the study cases, the maximum authorized train speed was greater than 30 mph, but stop signs were not present; in 20 of the study cases, the average daily train traffic was greater than 10, but stop signs were not present. The Safety Board is concerned that the use of stop signs is underutilized by the States.

The decision to install a stop sign, according to the 1993 guidance document developed by the FHWA and the FRA, is based on a determination of risk and is reasonable from a systems planning approach. The Board's study data, however, suggest that, given the level of risk present at all passive grade crossings, wider use of stop signs would increase safety. Rather than using engineering studies to determine that a stop sign is needed at a crossing, the Board believes that a more reasonable approach is for the States to use engineering studies to determine why a stop sign **should not** be placed at a crossing. Thus, the Board questions the need to limit the use of stop signs based on the 1993 guidance provided by the FHWA and the FRA but concurs with the guidance regarding the need for enforcement. The Safety Board concludes that installation and enforcement of stop signs at passive grade crossings would provide consistent information, instruction, and regulation to the motoring public and would improve the safety of the Nation's passive grade crossings. The Board recognizes that the FHWA and the FRA believe that the use of stop signs at certain crossings may increase the risk to the traveling public; for example, crossings where there is a steep ascending grade on the approach to or through the crossing. However, the Safety Board believes that the States should, within 2 years of receiving Federal funding, install stop signs at all passive grade crossings unless a traffic engineering analysis determines that installation of a stop sign would reduce the level of safety at a crossing. Crossings where conditions are such that the installation of stop signs would reduce the level of safety should be upgraded with active warning devices or should be eliminated.

The Safety Board considered whether stop signs should be installed only at dangerous passive crossings rather than at all passive crossings. The Board rejected this option for a number of reasons. First, if stop signs were installed only at dangerous crossings, the goal of uniformity of signs at all passive crossings would be defeated. Second, if stop signs were installed only at dangerous crossings, a new sign would be needed at the crossings without stop signs because neither the advance warning sign nor the crossbuck at those crossings instructs the driver what action is needed. Further, it would be several years before a new sign would be developed, rulemaking enacted, and

Table 6–2. Presence of stop signs at the study accident crossings relative to FHWA/FRA guidance for the installation of stop signs at passive grade crossings.

Considerations for installing stop signs at passive grade crossings[(a)]	Number of study accident crossings where stop signs were—	
	Present	Not present
Average daily highway traffic:		
<400 vehicles (signs recommended)	7	13
>400 vehicles	9	10
Unknown	6	15
Total	22	38
Angle of roadway–track intersection:		
Not 90° (signs recommended)	9	18
90°	13	20
Total	22	38
Sight distance:		
Limited (signs recommended)	13	20
Not limited	9	15
Unknown	0	3
Total	22	38
Average daily train traffic:		
>10 trains (signs recommended)	17	20
<10 trains	5	17
Unknown	0	1
Total	22	38
Number of tracks:		
Multiple tracks (signs recommended)	6	6
Single tracks	16	32
Total	22	38
Maximum train speed:		
>30 mph (signs recommended)	20	36
< 30 mph	2	2
Total	22	38
Passenger train use:		
Rail line used (signs recommended)	8	8
Rail line not used	14	29
Total	22	38

[(a)] The considerations are outlined in Attachment 2 to a memorandum from the Associate Administrator for Safety and Systems Applications, Federal Highway Administration, and the Associate Administrator for Safety, Federal Railroad Administration, issued on July 8, 1993, to the FHWA Regional Administrators and the FRA Regional Directors of Railroad Safety.

the new sign installed. During that time, interim technology for intelligent transportation systems is likely to be available that could alert motorists to the presence of a train.[159] Accordingly, to ensure a systematic and uniform approach to signage at passive crossings, the Safety Board chose to recommend the use of stop signs at all passive crossings unless a traffic engineering analysis determines that installation of a stop sign would reduce the level of safety at a crossing.

In 1996, there were 198,985 public and private passive crossings; installation of stop signs, and the associated stop ahead signs, is estimated to cost between $1,200 and $2,000 per crossing. The Safety Board believes that the DOT should provide full funding within 3 years for the installation of stop and stop ahead signs at passive grade crossings.

Advance Warning and Crossbuck Signs

The Safety Board considered whether the railroad crossing advance warning sign or crossbuck sign present at passive crossings should be replaced with a sign that (1) was unique to passive crossings, and (2) instructed the driver what action to take at the crossing. This issue was raised because neither the advance warning sign nor the crossbuck sign instructs a highway vehicle driver what to do—such as stop, yield, or take any action—at a passive crossing. The Safety Board's study indicates that the existing signs are sufficient to advise drivers of the presence of a crossing, and in the Safety Board's sample, most of the surviving drivers reported that they were aware of the crossing. The Safety Board is particularly concerned about drivers who are familiar with an area and are thus aware, from previous use, of the presence of a crossing. In these circumstances, ensuring that the driver looks for a train is of paramount importance. The Safety Board determined that if drivers are stopped at a crossing, they are in a better position and more likely to look for a train, in most cases. Thus, the Safety Board is recommending that stop signs be installed at passive crossings. Although installation of stop signs will not result in a sign that is unique to passive crossings, stop and stop ahead signs adequately communicate the driver action necessary at the crossing. In the Board's opinion, there is no need to replace either the current advance warning sign or the crossbuck sign.

Because the crossbuck sign does not dictate the action required by a driver, the Safety Board questions whether the crossbuck is appropriately classified as a regulatory sign. The Board is not recommending that the FHWA change the classification, however, because such a change would be an administrative action and does not affect safety.

[159] The report discusses intelligent transportation systems technology in greater detail later in this chapter.

DOT Crossing Identifier

Where possible, Safety Board staff compared data in the FRA inventory database (GCIS) on crossings involved in the study accidents with the data collected by investigators at the time of the accident. To search the database, staff needed the DOT crossing identifier, the unique ID number assigned to each crossing. According to the FRA, "[e]very crossing in the United States, including public, private and pedestrian, both at grade and grade separated shall have a crossing inventory number assigned and recorded in the National File." Further, the FRA recommends that this unique number "be displayed on both sides of the track at each and every crossing;"[160] that is, every crossing should be posted with its number. About one-third (19) of the study accident crossings in the Board's sample did not have the number posted, and 2 had incorrect numbers posted (cases 12 and 61).[161] In one case (case 61), for example, the railroad company owning the crossing had recycled signposts from another crossing and left the old ID numbers intact on the posts.

The DOT crossing ID number was created and set in place so that the various local authorities, State and Federal agencies, and the railroads would all have a common method by which to refer to a particular crossing. The DOT crossing ID number enables a county highway engineer, for example, to more easily communicate with a railroad about a crossing at which there will be work crews. More importantly, if used correctly, this number enables local police to notify railroads of trouble at a specific crossing, or the railroad to identify to local emergency response personnel exactly where a grade crossing accident has occurred. Any of this communication, some of it directly related to safety, would have been impossible at one-third of the crossings in the study sample. The Safety Board is concerned, given the number of crossings with a missing or incorrect ID number in the study sample, that ID numbers may be missing or incorrect at many other crossings throughout the system. The Board therefore believes that the FRA, the Association of American Railroads (AAR), and the American Short Line and Regional Railroad Association should encourage the railroads to ensure that the DOT identification number is properly posted at all grade crossings.

[160] Federal Railroad Administration, Office of Safety. 1996. Highway-rail crossing inventory instructions and procedures manual. Washington, DC. (p. 2-5).

[161] In 17 of these 21 cases, the Board found the appropriate number by looking at track charts or private crossing agreements, or someone at the railroad was able to provide it. At 4 of these 21 crossings (cases 32, 37, 57, and 58), the Board performed searches in the database using more general information, such as railroad name, State, and County names; this general search succeeded in identifying only 1 of the 4 crossings (case 32).

Enforcement Activities at Crossings

According to the AAR Railroad Industry Grade Crossing Policy Agenda, "the violation of traffic laws relating to highway–rail grade crossings is the single most significant factor in grade crossing incidents. . . . Incidents annually occur at grade crossings at which traditional highway 'stop' signs have been installed."[162]

The 1994 DOT Action Plan developed by the four modal administrations (described in chapter 2) outlined several initiatives to increase enforcement of traffic laws at crossings. One initiative involved the use of Section 402[163] funds to promote targeted public education, and engineering and law enforcement strategies. The NHTSA and the FHWA have advised the States that Section 402 funds are available for this purpose. The initiative is continuing, and in fiscal year 1997, 15 States dedicated $346,661 for this purpose.

Other enforcement initiatives outlined in the Action Plan included identifying and detailing a police officer with training background to work with the FRA and Operation Lifesaver in developing an outreach program to the enforcement community. According to a summary status of Action Plan initiatives received by the Safety Board from the FRA Office of Safety on May 27, 1998, one officer for each of the last 3 years has been detailed to the FRA and the outreach program is continuing. As part of an outreach to judicial officials, the NHTSA and the FHWA have prepared and published two articles in the National Traffic Law Center newsletter on the need for increased enforcement of traffic laws at active and passive crossings. The two modal administrations have also made a presentation on this issue at a traffic court judges' seminar and have published a pamphlet for distribution to judicial officials. The pamphlet emphasizes how judicial support can help reduce the number of accidents and fatalities at grade crossings through the use of fines and penalties; it also provides the judges with names of individuals to contact within the FRA.

The FHWA and the American Association of Motor Vehicle Administrators (AAMVA) have discussed the need for grade crossing violations to be considered as "serious" for holders of a commercial driver's license. Conviction of a serious violation can result in a suspended license as opposed to only a traffic fine. A notice of proposed rulemaking (NPRM) was issued on this topic on March 2, 1998. The comment period ended May 1, 1998; the FHWA Office of Motor Carriers is currently reviewing the comments.[164]

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[162] The AAR Policy Agenda, developed in 1994 and revised in 1998, summarizes the Association's recommendations for improving the safety at highway-rail grade crossings.

[163] 23 U.S.C. §402 authorizes the Secretary of the DOT to approve and provide funding for certain State highway safety programs.

[164] Information provided by the Office of Motor Carriers, July 13, 1998.

A witness at the Safety Board's public forum reported on enforcement efforts in Missouri. The witness acknowledged that in Missouri about 50 percent of the collisions occur at grade crossings with an ADT count of 500 highway vehicles or less; 25 percent of the collisions occur at grade crossings where the ADT is 50 vehicles or less.[165] His observation was that most of the collisions involved local people familiar with the area and the grade crossing. He provided these numbers as a preface to his remarks that law enforcement at passive grade crossings within his State is nonexistent and that scarce resources cannot be diverted from other high priority areas to focus on passive crossings.

The Safety Board acknowledges that a considerable proportion of passive crossings lie in rural regions on roads with fairly low traffic volume. In addition, casualties at grade crossings represent a very small percentage of overall highway casualties and, concurrently, a small part of law enforcement resources. Nevertheless, over 2,000 accidents occur each year at passive crossings. The Safety Board is aware that Operation Lifesaver (OL) organizations in several States have completed some innovative law enforcement programs that address enforcement of grade crossing warning devices.[166] These efforts are primarily targeted at locations with active warning devices, but some of the programs have addressed enforcement of stop signs at passive crossings. These programs, some entitled "Trooper on the Train," "Officer on the Train," or "Operation Stopgate," are often run sporadically; Ohio, however, runs about 11 or 12 trains per year because of strong coordination between the full-time OL coordinator and the law enforcement community and because of the interest of law enforcement in this initiative. Generally, the rail corridors targeted for these enforcement trains are selected because of high accident rates and the number of highway vehicle drivers who do not comply with active and passive warning devices. For the most part, these programs follow the same basic format: law enforcement officers are placed on the train and at stationary locations on either side of the grade crossings that are targeted for the program. Highway vehicle operators who do not comply with the lowered arm of a crossing gate and/or a flashing light or stop sign, and to a much lesser degree the crossbuck sign, are stopped by law enforcement officers and are ticketed. These programs also include video cameras that record the actions of the highway vehicle driver crossing in front of the train. The Safety Board emphasizes that one of the fundamental considerations that must be met for stop signs to be effective is that law enforcement officials must commit to a vigorous program of enforcement equal to the enforcement of stop signs at highway intersections. The Safety Board encourages OL and the States to continue the innovative approaches to enforcement. The AAR stated in its Policy Agenda that Federal highway safety "bonus awards" should be given to States for innovative pilot programs to increase enforcement of grade crossing traffic laws. The

[165] From remarks by a representative of the Missouri State Police. In: Transcript of the NTSB public forum on safety at passive grade crossings (pages 84-85).

[166] Telephone conversations of Safety Board staff with the OL coordinators in selected States (North Carolina, Ohio, Alabama, Georgia, and Florida) that have enforcement programs.

Safety Board concurs with this position and, therefore, believes that the DOT should provide Federal highway safety incentive grants to States to advance innovative pilot programs designed to increase enforcement of passive grade crossing traffic laws.

Grade Crossing Safety Education

The Safety Board's study indicates that the motoring public does not clearly understand the level of risk at passive crossings and the need for full driver attention each time a crossing is used. Further, in a 1988 survey conducted by the University of Tennessee, researchers asked drivers what motorists should do when approaching a crossing that does not have railroad signals. In response, 24.3 percent of the drivers said that the driver should slow down and be prepared to stop (which was determined by the researchers to be the correct response), 69.6 percent declared that one should "stop, look, and listen at the crossing for a train," and 6.1 percent stated that the question was "not applicable, because all crossings have railroad signals."[167]

When stopped at the crossing, as recommended in this report, a driver will be required to look for a train and judge the speed of a train if present. The Safety Board examined material from various driver educational programs to determine if passive crossings, the inherent risk at these crossings, and the driver's tasks were adequately addressed.

Highway safety education is provided to motorists by several organizations. The AAMVA, founded in 1933, is a voluntary, not-for-profit educational organization representing the State and provincial officials in the United States and Canada who are responsible for the administration and enforcement of motor vehicle laws. The AAMVA serves as an "information clearinghouse" for motor vehicle administration, police traffic services, and highway safety.[168] The Professional Truck Drivers Institute of America (PTDIA) develops curriculum and certification standards for training entry-level truck drivers. Operation Lifesaver (OL) is a not-for-profit organization that provides information about grade crossing safety to motor vehicle operators through safety educational programs.[169] The American Automobile Association (AAA) has been involved in driver education since the mid-1930s. The AAA writes and provides driver education materials

[167] Richards, Stephen H.; Heathington, K.W. 1988. Motorist understanding of railroad-highway grade crossing traffic control devices and associated traffic laws. In: Traffic control devices 1988. Transportation Research Record 1160. Washington, DC: Transportation Research Board, National Research Council: 52-59.

[168] Information obtained on May 4, 1998, from the Web site of the American Association of Motor Vehicle Administrators: http://www.aamva.org/aboutaamva.html.

[169] OL volunteers give speeches at schools and community associations, and prepare exhibits for regional fairs, in addition to other activities.

for use in high school and in professional driver's schools, conducts programs to assist driver education teachers with their preparations, and also conducts driver improvement programs for the general population.[170]

A review of the driver education material developed by the above organizations found that very little information is provided on the dangers of passive grade crossings or what actions are required of drivers at passive crossings. The AAA materials reviewed by the Board specify that passive grade crossings require more care on the part of the driver but do not discuss physical characteristics at grade crossings that can affect the driver's ability to see an approaching train. The PTDIA course outline material reviewed by the Board makes no mention of grade crossings.

Further, a review of the OL *Presenter Trainer's Manual* found that the section on school bus driver presentation, as mentioned earlier, addresses the visual illusions to which a driver is subject. However, the manual does not contain information about the unique problems present at passive grade crossings that require full driver attention, nor does it discuss how the physical characteristics of the crossing may affect the driver's ability to see a train approaching. Attendees at OL courses may not be aware of the unique dangers present at passive grade crossings because OL presentations do not address issues specific to passive grade crossings. The Safety Board is also concerned that the States' written driver examination may not always address issues specific to the dangers of passive grade crossings. According to one witness at the Safety Board's public forum, the motor vehicle administration in his State has five versions of the written driver's examination, only two of which contain a single question about grade crossings.[171] The Safety Board concludes that the dangers of passive grade crossings are not adequately addressed in current driver education material or in the States' written driver examinations. The Safety Board believes, therefore, that the States should ensure that questions on safety at passive grade crossings are included in every version of the State's written driver examinations. Further, the Safety Board believes that Operation Lifesaver, the American Association of Motor Vehicle Administrators, the American Automobile Association, and the Professional Truck Drivers Institute of America should include in their training manuals, presentations, and printed educational material information about (1) the need for full driver attention at passive grade crossings, (2) the fact that trains are often moving faster than they appear to be from a distance, and (3) the ways in which the physical characteristics of the crossing affect the driver's ability to see an approaching train at a passive crossing. The Safety Board also believes that OL, the AAMVA, the AAA, and the PTDIA should develop, in conjunction with the DOT, an appropriate training module specific to safety at passive grade crossings to be included in the organizations' highway safety education programs.

[170] Telephone conversation with staff at the national office of the AAA, May 13, 1997.

[171] Remarks by a representative of the Missouri State Police. In: Transcript of the NTSB public forum on safety at passive grade crossings (page 96).

Concurrent with the installation of stop signs at all passive crossings is the need to inform the Nation's motorists of the need to stop at all passive crossings. The Safety Board believes that a national media campaign is warranted to inform motorists of newly installed stop signs at passive crossings. The Advertising Council, Inc., has experience in developing messages to the public in an understandable manner and has worked with the DOT modal administrations on prior highway safety public service announcements. Therefore, the Safety Board believes that the DOT, in conjunction with the Advertising Council, should develop a media campaign to inform motorists that stops signs will be installed at many of the Nation's passive grade crossings, and to inform motorists of the importance of obeying stop signs at passive grade crossings.

Intelligent Transportation Systems

The MUTCD indicates that stop signs should be an interim measure until active warning devices can be installed. The Safety Board concurs that stop signs are an interim measure and believes that a long-term solution to eliminating passive crossings and reducing collisions between highway and rail vehicles will be through the use of intelligent transportation systems (ITS) that will be able to alert the motorist to the presence of a train.[172]

Subcomponents of ITS that are applicable to grade crossings include in-vehicle safety advisory and warning systems (IVSAWS) that use modern telecommunications technology to broadcast a warning to specially equipped highway vehicles.[173] The IVSAWS consist of a device to detect the presence of a train (this may be a transmitter on the locomotive, or a detection circuit at trackside) that sends a signal to a transceiver at the grade crossing, which, in turn, sends a signal to the receiver on the highway vehicle.

The IVSAWS are not intended to serve only as a warning about trains. The ultimate objective of this part of the ITS program and the organizations developing the technology is to design a system to warn drivers about numerous dangers on the roadway. When fully implemented, the IVSAWS could warn drivers about such things as the approach of police or emergency vehicles, the presence of a stopped school bus, and the approach of a train at a crossing. Given this multiple functionality, it will be necessary to enable the driver to determine easily which hazard to look for. Guidelines and specifications for appropriate visual displays and audible messages are currently being developed.

[172] ITS is a cooperative effort between government and private entities to integrate modern computer and communications technology into the transportation infrastructure. Its purpose is to test and to develop technology, and to establish standards for enabling uniform application of that technology throughout the Nation. (Information on the role of the Federal Government in ITS was obtained on February 4, 1998, from the Web site of the DOT's ITS Joint Programs Office: http://www.its.dot.gov/qa.web2.htm.)

[173] Some of these systems are also referred to as "vehicle proximity alerting systems" (VPAS).

The automobile manufacturers, recognizing that they will play an integral role in the implementation of systems like IVSAWS, are active to different degrees in the development of the equipment and the standards. For example, several manufacturers are members of the Intelligent Transportation Society of America (ITS America), the umbrella organization established by Congress in 1991 to coordinate development and deployment efforts in ITS.[174] Participation in ITS America permits the automobile manufacturers to keep informed of developments related to roadway and trackside equipment and to participate in the standards development committees. The Safety Board is encouraged by the efforts made by the automobile manufacturers to keep themselves aware of ITS developments and urges their active participation in all aspects of the development process.

ITS applications cost far less than installing lights and gates and will also convert passive crossings into active crossings. For the train detection and transmitting equipment for IVSAWS at each crossing, most cost estimates are below $5,000 per crossing, and all cost estimates are below $10,000 per crossing.[175] As noted earlier, it costs about $150,000 per crossing for standard warning devices. Depending on the cost of the ITS infrastructure, it is likely that the cost of ITS technology will be less than that for standard active warning devices. The Safety Board supports efforts to encourage development of ITS applications.

Unlike the gates and lights, however, the IVSAWS require, as a rule, a direct cost to the driver of each highway vehicle, who must either purchase and install an aftermarket device or pay extra for the system installed in a new car. Because the system will work best when every vehicle on the road carries the receiver, the practicality of these devices will depend on their near-universal availability in highway vehicles. Currently, estimated prices for the receivers range from about $50 up to $250.[176] The Safety Board recognizes that once the in-car technology is available, it will take 15 to 20 years before all vehicles on the road are equipped with the technology.

The Safety Board believes that interim ITS solutions may also be possible, such as signs or signals that can alert a motorist to the presence of a train without depending on expensive track circuitry. Less complex ITS applications have been proposed by the FHWA for use at grade crossings, including variable message signs and roadside beacons activated by wireless communications signals emitted by train detection equipment.[177] One proposed solution being tested by the Burlington Northern Santa Fe and the Union

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[174] According to ITS America (http://www.itsa.org/), the following automobile manufacturers are members: Chrysler, Ford, General Motors, Honda, Mazda, Nissan, and Toyota.

[175] The cost for the ITS infrastructure (global control and communications technology to be used everywhere) is not included in these estimates.

[176] One proposed system piggybacks its warning device onto the vehicle radio, and any extra cost is hidden from the consumer.

[177] Federal Highway Administration. 1997. Highway rail intersections. Standards Requirements Package 12. (Prepared by the Architectural Development Team, Lockheed Martin Federal Systems, Rockwell International.)

Pacific railroads is to utilize Global Positioning System tracking and computer projections to accurately determine a train's actual speed and position, and radio frequency satellite communications to activate whatever variable message signs or roadside beacons are installed at crossings in time to give motorists sufficient warning of the train. The grade crossing component of this project is being tested by the Texas Transportation Institute on the Pacific Northwest high speed rail corridor.[178] Equipment that communicates with the crossing warning devices has been successful in laboratory tests and will be field-tested in the summer of 1998, according to personnel at the Institute. Cost estimates for the grade crossing equipment are not yet available.

Other systems are being tested as a part of the Transportation Research Board's Innovations Deserving Exploratory Analysis (IDEA) program. For example, two proposed systems use different radar technologies to detect the presence and the speed of an approaching train, and then activate the warning devices. In the case of one of the radar systems just mentioned, the final contract is being completed, and therefore testing has not commenced. In the case of the other radar system, field testing will be conducted during the summer of 1998, and a viable product is expected by September.[179]

The Safety Board concludes that IVSAWS and other ITS applications proposed have the potential to reduce accidents and injuries at passive grade crossings by alerting drivers to an oncoming train. They appear to be less costly and more effective than installation of active warning devices for passive grade crossings. Initial testing of five IVSAWS was completed by the FRA in 1995, and two of the systems tested were determined to merit further testing, which was scheduled to begin early in 1998.[180] At the time this report was prepared, however, the testing had not yet been scheduled. Two States are currently funding tests of two different IVSAWS at railroad grade crossings independent of the U.S. Department of Transportation. In addition, several other IVSAWS have been developed, including systems in Italy and in portions of the United States, that warn drivers about several different highway hazards, such as hidden driveways and construction zones; the Italian system is already in use in more than 50,000 highway vehicles.[181] Given that several systems have proven effective and the potential of ITS to reduce accidents at passive crossings, the Safety Board believes that efforts to test and implement these systems should be a high priority. Therefore, the Safety Board believes that the DOT should (1) develop and implement a field test program for IVSAWS, variable message signs, and other active devices, and then (2) ensure that the private entities who are

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[178] Roop, Stephen. 1997. Specific applications of ITS to grade crossings. In: Intelligent transportation systems and their implications for railroads: Proceedings, Joint FRA-ITS America Technical Symposium; 1997 June 4-5; Washington, DC. DOT/FRA/ORD-97/11; DOT-VNTSC-FRA-97-8. Washington, DC: U.S. Department of Transportation, Federal Railroad Administration. Washington, DC: VI-1 to VI-7 (page VI-1).

[179] Telephone conversation with staff of the Transportation Research Board, ITS-IDEA Program, May 8, 1998.

[180] Telephone conversation with the FRA project manager, January 27, 1998.

[181] Briefing for Safety Board staff on May 20, 1997, by representatives of the Italian manufacturer, Electronic Security Systems Equipment Generation International Corporation.

developing advanced technology applications modify those applications as appropriate for use at passive grade crossings. Following the modifications, the DOT should take action to implement use of the advanced technology applications. Because of the multimodal nature of this technology, the Safety Board believes that it would be prudent for the modal administrations—including the NHTSA, the FHWA, and the FRA—and the modal associations—including the American Association of State Highway and Transportation Officials, the Association of American Railroads, the American Short Line and Regional Railroad Association, and the American Public Transit Association—to participate and cooperate fully with the ITS development.

Some ITS applications utilize technologies already in existence. For example, a representative of an automobile manufacturer has informed Safety Board staff that vehicles with a remote control door lock/unlock feature are already equipped with short-range receivers, a technology that could be adapted to suit the purposes of IVSAWS. The current generation of proposed IVSAWS includes systems that make use of radios currently on the market, and one that uses well-established radar detector technology. This means that the process of adapting and testing current technologies is faster than a process in which fundamentally new technology must be developed. However, each of the proposed systems uses a different radio frequency and utilizes different message codes to indicate the presence and type of hazard; if all are viable, there is a potential for implementation of different systems in different regions of the country. Should this become true, motorists could not rely on the warning from the system in their vehicle when traveling from one region to another. There is a need, therefore, for the establishment of national standards for radio frequencies to be used, auditory alerts, and specific message codes to be sent. The DOT, rather than imposing standards, is, in conjunction with ITS America, supporting, guiding, and funding the efforts of five standards development organizations in determining the standards for all ITS applications. According to information provided by the DOT, however, these standards are not yet in place for ITS at grade crossings, nor has any timetable been established for publishing these standards.[182] In fact, it has not yet been determined which standards need to be developed,[183] and until they are developed, there is no guarantee that any ITS system would be uniformly applied across the Nation. The Safety Board concludes that in order to achieve the greatest safety at passive grade crossings as quickly as possible, standards for ITS applications must be established in a timely manner. The Safety Board believes that the DOT should establish a timetable for the completion of standards development for ITS applications at highway–rail grade crossings, and it should act expeditiously to complete the standards.

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[182] Telephone conversation with the standards program manager at DOT's ITS Joint Program Office, June 8, 1998.

[183] Telephone conversation with the director of systems integration, ITS America, May 18, 1998.

Private Crossings

Fourteen of the study accidents occurred on private roads, including farm, residential, commercial, and industrial access roads. Seven of these 14 accidents were fatal, resulting in 11 fatalities. Five of the private crossings in the study did not have the standard crossbuck sign: three had special "private crossing" signs (figure 6–1), and two had no signs. Four private crossings in the study had multiple tracks but did not have the appropriate multiple tracks sign. None of the private crossings in the study had railroad crossing advance warning signs. Seven of the roads leading to the private crossings in the study were paved with asphalt; only one had pavement markings. Of the four private crossings in the Board's study for which ADT was available, two reportedly had fewer than 20 highway vehicles per day, one crossing had more than 1,000 vehicles, and one had an ADT of over 500 vehicles per day.[184]

Of the 14 private crossings in the study, 5 had sight obstructions: 3 had limited sight distance for a motorist approaching the crossing, 1 had limited sight distance for a motorist stopped at the crossing, and 1 had limited sight distance both on the approach to and for a vehicle stopped at the crossing. Six of the private crossings had curves in either the roadway or the track, and three had angles of intersection that were not 90°.

According to FRA records, about half of all passive grade crossings are on private roadways, about 99 percent of the private crossings are passive, and private passive crossings account for about 15 percent of all passive grade crossing fatalities. Crossings determined to be on private roads are not subject to and, as illustrated in the study cases, rarely comply with requirements for highway design, signage, or pavement markings. The FHWA does not in any way regulate passive crossings on private roads, and the FRA's oversight is limited to operations on the railroad rights-of-way. Although some railroads make it a policy to see that a crossbuck has been placed at every crossing, there is no Federal requirement that the sign be placed at every private crossing. Further, maintenance at railroad crossings may be subject to contractual obligations, but where it is not, maintenance is at the discretion of the landowner.

The extent to which States assume the responsibility for private crossings varies. Oregon, for example, recently enacted legislation to give the State jurisdiction over private crossings on high speed rail lines. Many States, however, have no laws about private crossings. Further, some States require special private crossing signs; other States do not. This lack of uniformity in signs leads to a system wherein drivers do not receive consistent information about the action to take at passive grade crossings, whether public or private.

[184] An ADT of 500–1,000 is not considered low, but these were industrial crossings, which might be expected to have more traffic than, for example, a farm crossing would have.

Figure 6–1. Private crossing sign used by some railroads at private crossings on their property.

Closure of private crossings is accomplished through an agreement between the landowners and the railroad. Problems may arise if ownership of the private road is unknown. According to an official of one railroad, only 20 percent of the 22,000 private grade crossings on the railroad's property had any written formal agreements between the railroad and the landowner.[185]

With respect to private crossings, the FHWA and FRA 1994 Action Plan stated the following:

> [The] FRA has traditionally taken the position that private crossing matters should be settled by the private parties involved. However, from a safety perspective, this approach has proven inadequate. A few states, including Alaska and California, have also reached this conclusion and have acted to standardize responsibilities and treatments for private crossings.[186] Despite this, the overall national result is that responsibilities are most often undefined or are inconsistently acknowledged and applied.

[185] Remarks by an official of Union Pacific Railroad. In: Transcript of the NTSB public forum on safety at passive grade crossings (page 335).

[186] According to the Chief of Engineering and Operations of the Alaska Department of Transportation and Public Utilities, the State of Alaska published a policy on treatment of private grade crossings, but this policy is not acted upon in practice. According to an Agreements Engineer at Caltrans, a California State transportation agency, California does not have a policy regarding treatment of private grade crossings.

> Similarly, traffic control or traffic warning standards have been defined in only a few instances and are not consistently applied. The FHWA lacks jurisdiction, as do most state and local departments. FHWA has endorsed the concept of applying MUTCD warning device standards to private highway–rail crossings, but lacks the jurisdiction to follow through.

According to the Action Plan, "the Department [DOT] proposes to develop and provide national, minimum safety standards for private crossings and to eliminate the potential impediment to high speed rail operations proposed by private crossings." To accomplish this, the Action Plan outlined three initiatives. First,

> Operational definitions will be developed for each of the four categories [of private grade crossing—farm, residential, recreational, and industrial]. . . . As appropriate, minimum safety requirements, warning device standards, and responsibilities will be defined beginning with the category(ies) with the most severe problems; i.e., probably with Private Industrial Crossings.

The second initiative, according to the Action Plan, was that the FRA would hold an informal safety inquiry to further review the concept of defining minimum safety standards for private crossings, or for certain categories of crossings, "up to and including standards for closure and consolidation under certain conditions." According to the Action Plan, the inquiry would address the "allocation of responsibilities and costs associated with private crossings and the need for dispute resolution mechanisms regarding that allocation." The third initiative involved the "feasibility of placing gates with remotely activated cipher locks at private crossings." According to the Action Plan, "in this scenario, the gate would normally be closed and locked. A potential user would call the railroad dispatcher, possibly from a special call box at the crossing."

The summary status of the Action Plan received by the Safety Board from the FRA in May 1998 indicated that with respect to the first initiative outlined above, "statistics and comments from previous safety inquiry are being reviewed." With respect to the second initiative, the summary status indicated "pending time and resources." With respect to the third initiative, the summary status indicated that the States of New York and Oregon were studying the concept and that "demonstrations [were] being planned in both States."

The Safety Board acknowledges the proposed actions and initiatives outlined in the 1994 Action Plan. However, it appears, based on the summary status report received, that little progress has been made to complete these initiatives. Implementation of the first initiative outlined above would be a positive step toward addressing the issue of standardization and uniformity of signs. The Safety Board concludes that safety at private passive crossings would be enhanced if there were clear responsibility for their safety and maintenance, including the installation and maintenance of the standard traffic control devices outlined in the MUTCD. The Safety Board thus believes that the DOT, in conjunction with the States, should determine within 2 years governmental oversight responsibility for safety at private highway–rail grade crossings and ensure that traffic control on these crossings meets the standards within the *Manual on Uniform Traffic Control Devices*.

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Conclusions

1. In 1996, passive crossings accounted for about three-quarters of all grade crossings in the United States; although there is less highway and train traffic at passive crossings than at active crossings, passive crossings accounted for 54 percent of all grade crossing accidents and 60 percent of all grade crossing fatalities in that year.

2. A systematic and hierarchic approach to improving passive grade crossing safety is needed, an approach that does not depend primarily on the ability of the driver approaching the crossing to see an oncoming train. The hierarchic approach includes grade separation and closure, installation of active warning devices, improved signage, and intelligent transportation systems technology.

3. Consolidation (the separation and closure) of passive crossings is the most effective means to eliminate accidents between highway vehicles and trains. The next most desirable method to improve safety at passive crossings is to equip these crossings with active devices that warn the motorist of an oncoming train.

4. Installation and enforcement of stop signs at passive crossings would provide consistent information, instruction, and regulation to the motoring public and would improve the safety of the Nation's passive grade crossings.

5. Stop signs are an interim measure to improve the safety at passive grade crossings; the long-term solution to eliminating passive crossings and reducing collisions between highway and rail vehicles will be through the use of intelligent transportation systems that will alert the motorist to the presence of a train.

6. In-vehicle safety and advisory warning systems and other applications of intelligent transportation systems (ITS) have the potential to reduce accidents and injuries at passive grade crossings by alerting drivers to an oncoming train. In order to achieve the greatest safety at passive grade crossings as quickly as possible, standards for ITS applications must be established in a timely manner.

7. The sight distances available to a motorist, the crossing angle of intersection, the presence of curves on the roadway or on the tracks, and the presence of nearby roadway intersections can affect the level of safety at passive grade crossings. Not all States include these factors in the formulas used to determine the selection of crossings for elimination or improvement, and only the crossing angle of intersection and the presence of nearby roadway intersections are recorded in the Grade Crossing Inventory System of the Federal Railroad Administration.

8. A driver’s decision to look for a train may be adversely affected by the driver’s familiarity with and expectations at a specific passive grade crossing and the driver’s experience with passive crossings in general.

9. The action a driver needs to take at a passive grade crossing should be communicated to the driver at the point of the advance warning sign. The current set of traffic signs used at passive grade crossings does not do so.

10. Although the *Railroad–Highway Grade Crossing Handbook* by the Federal Highway Administration and *A Policy on Geometric Design of Highways and Streets* by the American Association of State Highway and Transportation Officials provide guidance to assist highway engineers in the physical and geometric design of safe roadway systems, the characteristics at 54 of the 60 study accident crossings failed to adhere to at least one of these guidelines. The safety of passive grade crossings is enhanced when their design adheres to the applicable standards and guidelines.

11. For stop signs at passive crossings to be most effective, law enforcement officials must commit to a vigorous program of enforcement.

12. The dangers of passive grade crossings are not adequately addressed in current driver education material or in the States’ written driver examinations.

13. In some circumstances, audible warning devices on trains fail to meet their objective of alerting motorists to an oncoming train because of highway vehicle design and environmental factors.

14. The safety at private passive crossings would be enhanced if there were clear responsibility for their safety and maintenance, including the installation and maintenance of the standard traffic control devices outlined in the *Manual on Uniform Traffic Control Devices*.

15. About one-third of the study accident crossings in the National Transportation Safety Board’s sample did not have the U.S. Department of Transportation identification number posted, and two had incorrect numbers posted. Exact communication about where a grade crossing accident occurred would have been impossible at these crossings in the study sample.

Recommendations

As a result of this safety study, the National Transportation Safety Board made the following recommendations:

To the Secretary, U.S. Department of Transportation—

> Provide full funding within 3 years for the installation of stop and stop ahead signs at passive grade crossings. (H-98-28)
>
> Provide Federal highway safety incentive grants to States to advance innovative pilot programs designed to increase enforcement of passive grade crossing traffic laws. (H-98-29)
>
> Develop, in conjunction with Operation Lifesaver, Inc., the American Association of Motor Vehicle Administrators, the American Automobile Association, and the Professional Truck Drivers Institute of America, an appropriate training module specific to safety at passive crossings to be included in the organizations' highway safety education programs. (H-98-30)
>
> Develop, in conjunction with the Advertising Council, Inc., a media campaign to inform motorists that stop signs will be installed at many of the Nation's passive grade crossings, and to inform motorists of the importance of obeying stop signs at passive grade crossings. (H-98-31)
>
> Develop and implement a field test program for in-vehicle safety and advisory warning systems, variable message signs, and other active devices; then ensure that the private entities who are developing advanced technology applications modify those applications as appropriate for use at passive grade crossings. Following the modifications, take action to implement use of the advanced technology applications. (I-98-1)
>
> Establish a timetable for the completion of standards development for applications of intelligent transportation systems at highway–rail grade crossings, and act expeditiously to complete the standards. (I-98-2)
>
> Determine within 2 years, in conjunction with the States, governmental oversight responsibility for safety at private highway–rail grade crossings and ensure that traffic control on these crossings meets the standards within the *Manual on Uniform Traffic Control Devices*. (H-98-32)

Develop a standardized hazard index or a safety prediction formula that will include all variables proven by research or experience to be useful in evaluating highway–rail grade crossings, and require the States to use it. (H-98-33)

To the Federal Railroad Administration—

Modify the Grade Crossing Inventory System to include information on (1) the sight distances available to a motorist, and (2) the presence of curves on the roadway and on the tracks. Direct the States to include these data as a part of the regularly scheduled updates of the database. (R-98-41)

Encourage the railroads to ensure that the U.S. Department of Transportation identification number is properly posted at all grade crossings. (R-98-42)

To the States—

Install, within 2 years of receiving Federal funding, stop signs at all passive grade crossings unless a traffic engineering analysis determines that installation of a stop sign would reduce the level of safety at a crossing. Crossings where conditions are such that the installation of stop signs would reduce the level of safety should be upgraded with active warning devices or should be eliminated. (H-98-34)

Determine within 2 years, in conjunction with the U.S. Department of Transportation, governmental oversight responsibility for safety at private highway–rail grade crossings and ensure that traffic control on these crossings meets the standards within the *Manual on Uniform Traffic Control Devices*. (H-98-35)

Evaluate periodically, or at least every 5 years, all passive grade crossings to determine compliance with existing guidelines of the Federal Highway Administration and the American Association of State Highway and Transportation Officials regarding sight distances, angle of intersection where the roadway meets the tracks, curves on the roadway or tracks, and nearby roadway intersections. For those crossings determined not to be in compliance with the guidelines, initiate activity to bring these crossings into compliance, wherever possible. Where passive crossings cannot be brought into compliance for reasons such as permanent obstructions at the stop line, target those crossings for installation of active warning devices, grade separation, or closure. (H-98-36)

Ensure that questions on safety at passive grade crossings are included in every version of the State's written driver examinations. (H-98-37)

To Operation Lifesaver, Inc., the American Association of Motor Vehicle Administrators, the American Automobile Association, and the Professional Truck Drivers Institute of America—

Include in training manuals, presentations, and printed educational material information about (1) the need for full driver attention at passive grade crossings, (2) the fact that trains are often moving faster than they appear to be from a distance, and (3) the ways in which the physical characteristics of the crossing affect the driver's ability to see an approaching train at a passive crossing. (H-98-38)

Develop, in conjunction with the U.S. Department of Transportation, an appropriate training module specific to safety at passive grade crossings to be included in the organizations' highway safety education programs. (H-98-39)

To the Advertising Council, Inc.—

Develop, in conjunction with the U.S. Department of Transportation, a media campaign to inform motorists that stop signs will be installed at many of the Nation's passive grade crossings, and to inform motorists of the importance of obeying stop signs at passive grade crossings. (H-98-40)

To the National Highway Traffic Safety Administration, the Federal Highway Administration, the Federal Railroad Administration, the American Association of State Highway and Transportation Officials, the Association of American Railroads, the American Short Line and Regional Railroad Association, and the American Public Transit Administration—

Participate and cooperate fully with the development of intelligent transportation systems that will be able to alert drivers to an oncoming train at passive grade crossings. (I-98-3)

To the Association of American Railroads and the American Short Line and Regional Railroad Association—

Encourage your member railroads to ensure that the U.S. Department of Transportation identification number is properly posted at all grade crossings. (R-98-43)

By the National Transportation Safety Board

James E. Hall
Chairman

Robert T. Francis II
Vice Chairman

John A. Hammerschmidt
Member

John Goglia
Member

George W. Black, Jr.
Member

July 21, 1998

Appendix A

FRA Data on Passive Grade Crossing Accidents, 1991–1996

Table A–1. Preliminary data regarding active and passive public highway–rail grade crossings in the United States, 1997.[a]

	All crossings	
Item	Active	Passive
Number of public crossings	61,564	99,491
Average daily highway traffic	4,003	849
Average daily train traffic	13.7	6.2
Number of accidents	1,541	1,717

[a] Preliminary numbers provided by the Federal Railroad Administration's Office of Safety Analysis, Systems Support Division.

Table A–2. Grade crossing data, 1991–1996.

	Public crossings		Private crossings		All crossings		
Data item and year	**Active**	**Passive**	**Active**	**Passive**	**Active**	**Passive**	**Total**
Number of grade crossings:							
1991	64,344	109,741	NA	NA	NA	NA	NA
1992	64,271	106,351	923	108,958	65,194	215,309	280,503
1993	64,396	103,720	971	107,381	65,367	211,101	276,468
1994	64,834	101,201	993	105,722	65,827	206,923	272,750
1995	65,096	98,821	1,034	103,725	66,130	202,546	268,676
1996	65,667	96,759	1,069	102,226	66,736	198,985	265,721
Number of grade crossing accidents involving highway vehicles:							
1991	2,394	2,283	62	433	2,456	2,716	5,172
1992	2,168	2,101	48	367	2,216	2,468	4,684
1993	2,138	2,102	45	376	2,183	2,478	4,661
1994	2,176	2,120	49	401	2,225	2,521	4,746
1995	2,001	1,971	42	402	2,043	2,373	4,416
1996	1,795	1,817	51	391	1,846	2,208	4,054
Number of fatalities in grade crossing accidents involving highway vehicles:							
1991	228	269	2	36	230	305	535
1992	185	281	1	39	186	320	506
1993	262	255	2	35	264	290	554
1994	214	287	1	40	215	327	542
1995	220	235	1	52	221	287	508
1996	168	209	0	38	168	247	415
Number of persons injured in grade crossing accidents involving highway vehicles:							
1991	969	897	20	143	989	1,040	2,029
1992	813	939	10	129	823	1,068	1,891
1993	797	880	7	76	804	956	1,760
1994	817	947	8	113	825	1,060	1,885
1995	749	947	11	118	760	1,065	1,825
1996	642	786	14	103	656	889	1,545

NA = not available. (The FRA did not begin publishing inventory information about private crossings until 1992.)

Source: U.S. Department of Transportation, Federal Railroad Administration. 1992–1997. Highway–rail crossing accident/incident and inventory bulletin. Nos. 14–19. Washington, DC. Annual.

Appendix B

Grade Crossing Signs as Illustrated in the MUTCD

Part VIII. TRAFFIC CONTROL SYSTEMS FOR RAILROAD — HIGHWAY GRADE CROSSINGS

A. GENERAL

8A-1 Functions

Traffic control systems for railroad-highway grade crossings include all signs, signals, markings, and illumination devices and their supports along highways approaching and at railroad crossings at grade. The function of these systems is to permit safe and efficient operation of rail and highway traffic over crossings. Traffic control devices shall be consistent with the design and application of the standards contained herein. For the purpose of installation, operation, and maintenance of devices constituting traffic control systems at railroad-highway grade crossings, it is recognized that any crossing of a public road and a railroad is situated on right-of-way available for the use of both highway traffic and railroad traffic on their respective roadways and tracks.

With due regard for safety and for the integrity of operations by highway and railroad users, the highway agency and the railroad company are entitled to jointly occupy the right-of-way in the conduct of their assigned duties. This requires joint responsibility in the traffic control function between the public agency and the railroad. The determination of need and selection of devices at a grade crossing is made by the public agency with jurisdictional authority. Subject to such determination and selection, the design, installation and operation shall be in accordance with the national standards contained herein.

8A-2 Use of Standard Devices

The grade crossing traffic control devices, systems, and practices described herein are intended for use both in new installations and at locations where general replacement of present apparatus is made, consistent with Federal and State laws and regulations. To stimulate effective reaction of vehicle operators and pedestrians, these devices, systems, and practices utilize the five basic considerations: design, placement, operation, maintenance, and uniformity employed generally for traffic control devices and described fully in section 1A-2.

8A-3 Uniform Provisions

All signs used in grade crossing traffic control systems shall be reflectorized to show the same shape and color to an approaching motorist both by day and by night. Reflectorization may be by one of the methods described in section 2A-18.

Normally, where the distance between tracks, measured along the highway, exceeds 100 feet, additional signs or other appropriate traffic control devices should be used.

No sign or signal shall be located in the center of an undivided roadway except in an island with barrier curbs installed in accordance with the general requirements of Part V with minimum clearance of 2 feet from the face of each curb.

Where it is practical, equipment housing should provide a lateral clearance of 30 feet from the roadway. Adequate clearance should also be provided from tracks in order to reduce the obstruction to motorists sight distance and to reduce the possibility of damage to the housed equipment.

8A-4 Crossing Closure

Any highway grade crossing for which there is not a demonstrated need should be closed.

8A-5 Traffic Controls During Construction and Maintenance

Traffic controls for street and highway construction and maintenance operations are discussed in Part VI of this manual. Similar traffic control methods should be used where highway traffic is affected by construction and maintenance at grade crossings.

Public and private agencies should meet to plan appropriate detours and necessary signing, marking, and flagging requirements for successful operations during the closing. Pertinent considerations include length of time for crossing to be closed, type of traffic affected, time of day, materials and techniques of repair. Inconvenience, delay, and accident potential to affected traffic should be minimized to the extent practical. Prior notice should be extended to affected public or private agencies before blockage or infringement on the free movement of vehicles or trains.

Construction or maintenance techniques should not extensively prolong the closing of the crossing. The width and riding quality of the roadway surface at a grade crossing should, as a minimum, be restored to correspond with the approaches to the crossing.

B. SIGNS AND MARKINGS

8B-1 Purpose

Passive traffic control systems, consisting of signs, pavement markings, and grade crossing illumination, identify and direct attention to the location of a grade crossing. They permit vehicle operators and pedestrians to take appropriate action.

Where railroad tracks have been abandoned or their use discontinued, all related signs and markings shall be removed. A sign, TRACKS OUT OF SERVICE (R8-9) may be installed until the tracks are removed or covered (see Section 8B-10). VIII-16 (c) Rev. 5

8B-2 Railroad Crossing (Crossbuck) Sign (R15-1, 2)

The railroad crossing sign, a regulatory sign, commonly identified as the "crossbuck" sign, as a minimum shall be white reflectorized sheeting or equal, with the words RAILROAD CROSSING in black lettering. As a minimum, one crossbuck sign shall be used on each roadway approach to every grade crossing, alone or in combination with other traffic control devices. If there are two or more tracks between the signs, the number of tracks shall be indicated on an auxiliary sign of inverted T shape mounted below the crossbuck in the manner and at the heights indicated in figure 8-1 except that use of this auxiliary sign is optional at crossings with automatic gates.

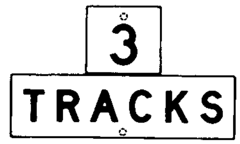
Where physically feasible and visible to approaching traffic the crossbuck sign shall be installed on the right hand side of the roadway on each approach to the crossing. Where an engineering study finds restricted sight distance or unfavorable road geometry, crossbuck signs shall be placed back to back or otherwise located so that two faces are displayed to that approach.

Crossbuck signs should be located with respect to the roadway pavement or shoulder in accordance with the criteria in sections 2A-21 through 2A-27 and figures 2-1 and 2-2 (pages 2A-9 and 2A-10) and should be located with respect to the nearest track in accordance with signal locations in figure 8-7, (page 8C-6). The normal lateral clearances (sec. 2A-24), 6 feet from the edge of the highway shoulder or 12 feet from the edge of the traveled way in rural areas and 2 feet from the face of the curb in urban areas will usually be attainable. Where unusual conditions demand, variations determined by good judgment should provide the best possible combination of view and safety clearances attainable, occasionally utilizing a location on the left-hand side of the roadway.

Appropriate details of R15-1 and R15-2 are available in Standard Highway Signs. *

* Available from GPO

R15–1
48" x 9"
(drilled for 90-degree mounting)



R15–2
9" x 9"
27" x 9"

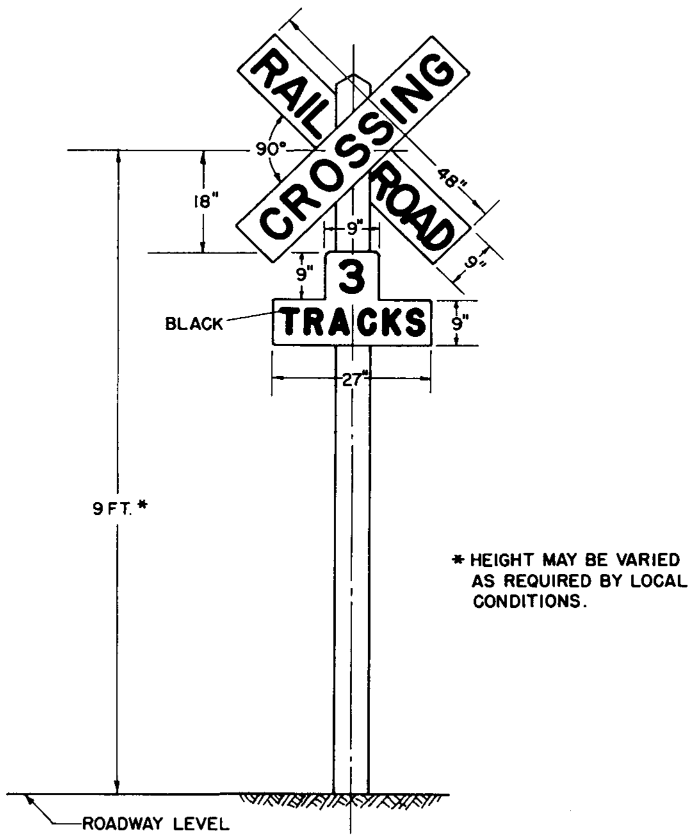


Figure 8-1. Railroad-highway crossing (crossbuck) sign.

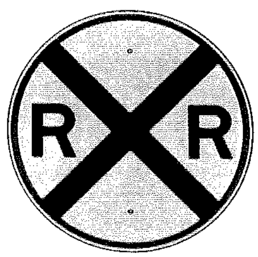
8B-3 Railroad Advance Warning Signs (W10-1, 2, 3, 4)

A Railroad Advance Warning (W10-1) sign shall be used on each roadway in advance of every grade crossing except:

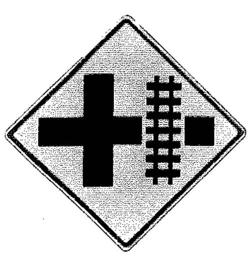
1. On low-volume, low-speed roadways crossing minor spurs or other tracks that are infrequently used and which are flagged by train crews.
2. In the business districts of urban areas where active grade crossing traffic control devices are in use.
3. Where physical conditions do not permit even a partially effective display of the sign.

Placement of the sign shall be in accordance with Table II-1, Section 2C-3 and Sections 2A-21 to 2A-27, except in residential or business districts where low speeds are prevalent, the signs may be placed a minimum distance of 100 feet from the crossing. On divided highways and one-way roads, it is desirable to erect an additional sign on the left side of the roadway. VIII-12 (c) Rev. 5

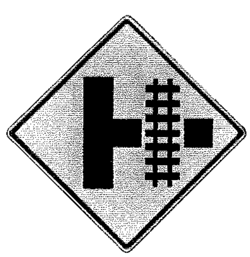
The W10-2, 3, and 4 signs may be installed on highways that are parallel to railroads. The purpose of these signs is to warn a motorist making a turn that a railroad crossing is ahead. Where there is 100 feet or more between the railroad and the parallel highway, a W10-1 sign should be installed in advance of the railroad crossing and the W10-2, 3, or 4 signs on the parallel highway would not be necessary.



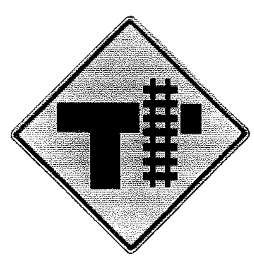
W10-1
36″ Diameter



W10-2
30″ × 30″

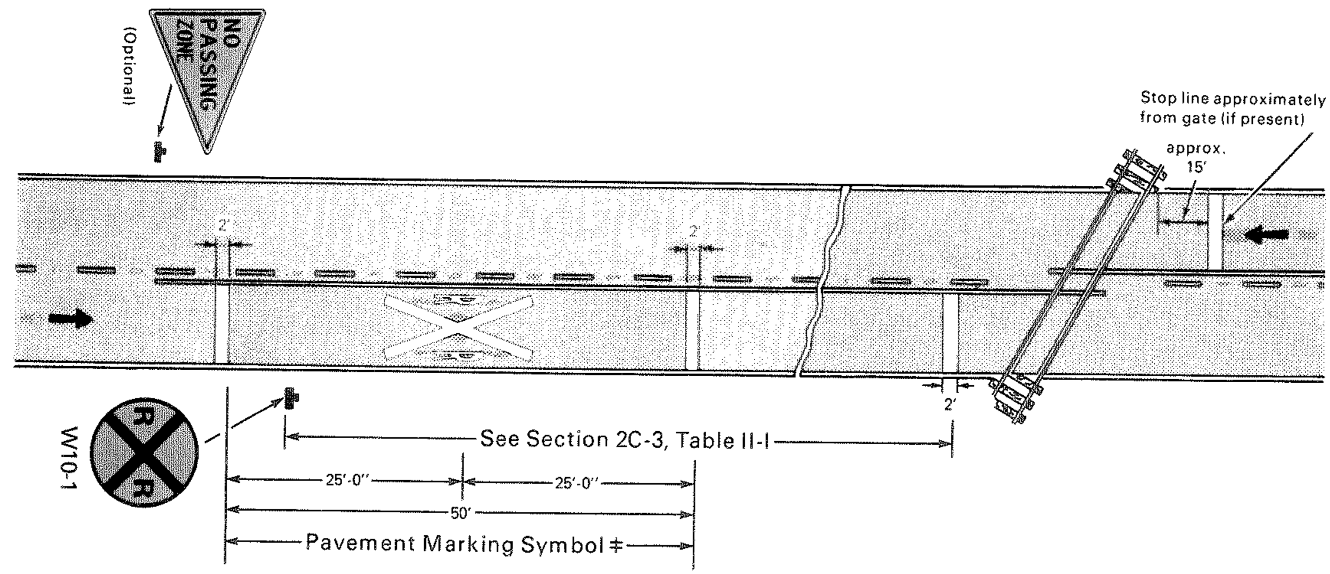


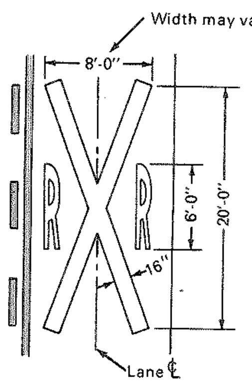
W10-3
30″ × 30″



W10-4
30″ × 30″

VIII-2 (c) Rev. 2





‡ When used, a portion of the pavement marking symbol should be directly opposite the Advance Warning Sign (W10-1). If needed, supplemental pavement marking symbol(s) may be placed between the Advance Warning Sign and the crossing, but should be at least 50 feet from the Stop Line.

A three lane roadway should be marked with a centerline for two-lane approach operation on the approach to a crossing.

On multi-lane roads the transverse bands should extend across all approach lanes, and individual RXR symbols should be used in each approach lane.

Refer to Standard Alphabet for Highway Signs and Markings for RXR symbols details.

Figure 8-2. Typical placement of warning signs and pavement markings at railroad-highway grade crossings.

8B–4 Pavement Markings

Pavement markings in advance of a grade crossing shall consist of an X, the letters RR, a no passing marking (2-lane roads), and certain transverse lines. Identical markings shall be placed in each approach lane on all paved approaches to grade crossings where grade crossing signals or automatic gates are located, and at all other grade crossings where the prevailing speed of highway traffic is 40 mph or greater. When used, a portion of the pavement marking symbol should be directly opposite the advance warning sign. If needed, supplemental pavement marking symbol(s) may be placed between the advance warning sign and the crossing. VIII–12 (c) Rev. 5

The markings shall also be placed at crossings where the engineering studies indicate there is a significant potential conflict between vehicles and trains. At minor crossings or in urban areas, these markings may be omitted if engineering study indicates that other devices installed provide suitable control.

The design of railroad crossing pavement markings shall be essentially as illustrated in figure 8–2. The symbols and letters are elongated to allow for the low angle at which they are viewed. All markings shall be reflectorized white except for the no-passing markings which shall be reflectorized yellow.

8B–5 Illumination at Grade Crossings

At grade crossings where a substantial amount of railroad operation is conducted at night, particularly where train speeds are low, where crossings are blocked for long periods, or accident history indicates that motorists experience difficulty in seeing trains or control devices during the hours of darkness, illumination at and adjacent to the crossing may be installed to supplement other traffic control devices where an engineering analysis determines that better visibility of the train is needed. Regardless of the presence of other control devices, illumination will aid the motorist in observing the presence of railroad cars on a crossing where the gradient of the vehicular approaches is such that the headlights of an oncoming vehicle shine under or over the cars.

Recommended types and location of luminaires for grade crossing illumination are contained in the American National Standard Practice for Roadway Lighting, RP8.* In any event, luminaires shall be so located and light therefrom so directed as to not interfere with aspects of the railroad signal system and not interfere with the field of view of members of the locomotive crew.

8B–6 Exempt Crossing Signs (R15–3, W10–1a)

When authorized by law or regulation a supplemental sign (R15–3) bearing the word EXEMPT may be used below the Crossbuck and Track

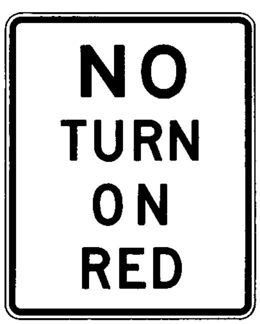
* Available from the Illuminating Engineering Society, New York, N.Y. 10017.

signs at the crossing, and supplemental sign (W10–1a) may be used below the railroad advance warning sign. These supplemental signs are to inform drivers of vehicles carrying passengers for hire, school buses carrying children, or vehicles carrying flammable or hazardous materials that a stop is not required at certain designated grade crossings, except when a train, locomotive, or other railroad equipment is approaching or occupying the crossing or the driver's view of the sign is blocked.

R15-3 White background
W10-1a Yellow background

8B–7 Turn Restrictions

At a signalized highway intersection within 200 feet of a grade crossing, where the intersection traffic control signals are preempted by the approach of a train, all existing turning movements toward the grade crossing should be prohibited by proper placement of a NO RIGHT TURN sign (R3–1) or a NO LEFT TURN sign (R3–2) or both. In each case, these signs shall be visible only when the restriction is to be effective. A blank-out, internally illuminated, or other similar type sign may be used to accomplish this objective. The signs shall be red and black on white and have a standard size of 24″ × 24″.



R10-11
24″ x 30″

R8-8
24″ x 30″

8B–8 Do Not Stop on Tracks Sign (R8–8)

VIII-1 Rev.

Whenever an engineering study determines that the potential for vehicles stopping on the tracks is high, a DO NOT STOP ON TRACKS sign (R8–8) should be used. The sign may be located on the right side of the road on the near or far side of the grade crossing, whichever provides better visibility to the motorist to observe the sign and be able to comply with its message. On multi-lane roads and one-way roadways a second sign may be placed on the near or far left side to the grade crossing to further improve visibility. Placement of the R8-8 sign(s) should be determined as part of the engineering study. VIII-11 (c) Rev. 5

8B-9 STOP Signs at Grade Crossings (R1-1, W3-1)

The use of the STOP signs at railroad-highway grade crossings shall be limited to those grade crossings selected after need is established by a detailed traffic engineering study. Such crossings should have the following characteristics:

1. Highway should be secondary in character with low traffic counts.
2. Train traffic should be substantial.
3. Line of sight to an approaching train is restricted by physical features such that approaching traffic is required to reduce speed to 10 miles per hour or less in order to stop safely. VIII-5 (c) Rev. 2
4. At the stop bar, there must be sufficient sight distance down the track to afford ample time for a vehicle to cross the track before the arrival of the train.

The engineering study may determine other compelling reasons for the need to install a STOP sign, however, this should only be an interim measure until active traffic control signals can be installed. STOP signs shall not be used on primary through highways or at grade crossings with active traffic control devices.

Whenever a STOP sign is installed at a grade crossing, a Stop Ahead sign shall be installed in advance of the STOP sign.

8B-10 Tracks Out of Service Sign (R8-9)

The TRACKS OUT OF SERVICE sign (R8-9) is intended for use at a crossing in lieu of the Railroad Crossing sign (R15-1, 2) when a railroad track has been abandoned or its use discontinued. This sign (R8-9) shall be removed when the tracks have been removed or covered. VIII-16 (c) Rev. 5

R8-9
24" × 24"

Appendix C

Status of Previous Safety Recommendations Pertaining to Passive Grade Crossings

Safety Recommendation No.: H-68-7
Date Issued: September 16, 1968
Recipient: States
Status: Closed—No Longer Applicable
Recommendation:

> Establish a requirement that the door of a school bus be opened for a sufficiently long period while stopped to allow the whistle or horn of a train to be heard at unprotected grade crossings, if your State does not now have such a requirement.

Safety Recommendation No.: H-68-17
Date Issued: September 16, 1968
Recipient: The Federal Railroad Administration, Office of High Speed Ground Transportation (FRA); The Association of American Railroads (AAR); Railroads operating the Northeast corridor; and States having safety regulatory authority over railroads
Status: FRA: Closed—Reconsidered
AAR: Closed—No Longer Applicable
Railroads operating in the Northeast corridor: Closed—No Longer Applicable
States: Closed—No Longer Applicable
Recommendation:

> Consider the implications of this accident analysis for logical and necessary train operating speed reductions under restricted visibility wherever tracks cross unprotected grade crossings.

Safety Recommendation No.: H-73-15
Date Issued: June 21, 1973
Recipient: The International Association of Chiefs of Police
Status: Closed—No Longer Applicable

Recommendation:

Use the Association's influence and resources to redirect the attention of law enforcement agencies to the need for uniform enforcement of traffic laws pertaining to railroad-highway grade crossings (1963 IACP resolution F-18, Highway Safety Policies for Police Executives). Such enforcement should provide special emphasis on those crossings protected solely with stop signs.

Safety Recommendation No.: H-80-41
Date Issued: May 14, 1980
Recipient: City of Spokane, Washington
Status: Closed—No Longer Applicable
Recommendation:

Examine the effects of closing Stone, Lee, and Crestline Street crossings using the Railroad-Highway Grade Crossing Handbook as a guide and take appropriate action to either close these crossings or install active crossing protective devices, and inform the Safety Board of the action taken.

Safety Recommendation No.: H-80-42
Date Issued: May 14, 1980
Recipient: City of Spokane, WA
Status: Closed—No Longer Applicable
Recommendation:

Erect railroad advance warning signs and pavement markings on Napa Street at the crossing with the Spokane International Railroad. The signs and markings and their installation should be in accordance with the Manual on Uniform Traffic Control Devices.

Safety Recommendation No.: H-80-43
Date Issued: May 14, 1980
Recipient: City of Spokane, Washington
Status: Closed—No Longer Applicable

Recommendation:

Prohibit the parking of railroad boxcars within the critical sight triangle of those railroad-highway grade crossings where only passive control devices exist. Require that flagmen be provided when such standing is necessary during loading or unloading.

Safety Recommendation No.: R-82-113
Date Issued: December 29, 1982
Recipient: State of Alabama
Status: Closed—Acceptable Action
Recommendation:

Install stop and stop ahead signs immediately on County Road 42 where it intersects the track of the Southern Railway Company.

Safety Recommendation No.: R-82-114
Date Issued: December 29, 1982
Recipient: State of Alabama
Status: Closed—Acceptable Action
Recommendation:

Immediately repaint the stop line east of the tracks and the centerline on both approaches of County Road 42 to the Southern Railway Company track.

Safety Recommendation No.: R-82-115
Date Issued: December 29, 1982
Recipient: State of Alabama
Status: Closed—Acceptable Action
Recommendation:

Complete the review of the recommendations of the diagnostic team that examined the Southern Railway system, County Road 42 crossing on October 4, 1982, and develop appropriate additional action as necessary.

Safety Recommendation No.: H-89-36
Date Issued: December 5, 1989
Recipient: Federal Highway Administration
Status: Closed—Reconsidered
Recommendation:

> Delete the provision contained in Section 392.10(b) of the Federal Motor Carrier safety regulations which permits certain vehicles transporting hazardous materials to cross railroad grade crossings used exclusively for industrial switching purposes without stopping and determining that it is safe to proceed.

Safety Recommendation No.: H-89-37
Date Issued: December 5, 1989
Recipient: National Tank Truck Carriers, Inc.
Status: Open—Await Response
Recommendation:

> Notify your membership of the facts and circumstances of the train/truck collision which occurred in Carteret, New Jersey, on December 6, 1988, and request your members to advise their hazardous materials truckdrivers not to cross over any grade crossing without stopping unless the crossing is marked as being exempt.

Safety Recommendation No.: R-81-96
Date Issued: October 6, 1981
Recipient: The Association of American Railroads
Status: Closed—Acceptable Alternate Action
Recommendation:

> Encourage railroads to develop programs for train crewmembers to report: (1) truck carriers identified as transporters of bulk hazardous materials, (2) crossings with passive warning devices which are used frequently by bulk hazardous materials trucks, and (3) bulk hazardous materials trucks which are involved in near-collisions.

Safety Recommendation No.: R-86-51
Date Issued: January 13, 1987
Recipient: Federal Highway Administration
Status: Closed—Reconsidered
Recommendation:

> Develop and require installation of a specific advance warning sign for grade crossing locations identified by States as hazardous at locations awaiting upgrade to an active warning device.

Safety Recommendation No.: R-86-52
Date Issued: January 13, 1987
Recipient: Federal Highway Administration
Status: Closed—Acceptable Action
Recommendation:

> Issue an "On Guard" bulletin to all motor carriers, advising that the audible warning systems currently used by passenger trains and high speed freight trains cannot be relied on to warn of a train's approach and that it is imperative that drivers approach any grade crossing with passive warning devices as an extremely hazardous location.

Appendix D

Agenda of the NTSB Public Forum on Passive Grade Crossing Safety

Jacksonville Hilton Hotel
Jacksonville, Florida

Thursday, May 8, 1997

8:30 a.m.–9 a.m.	**OPENING PRESENTATIONS:** **Welcome** The Honorable Robert Francis, Vice Chairman, National Transportation Safety Board **Overview of Grade Crossing Crashes** Mr. Robert Lauby, Chief, Railroad Division, National Transportation Safety Board **Grade Crossing Issues in Europe** The Honorable Giuseppe Soriero, Undersecretary of Rail and Navigation, Italian Ministry of Transportation and Navigation
9 a.m.–9:30 a.m.	**PANEL 1: Grade Crossing Collision Experiences** Mrs. Jennifer Duval, New Castle, Indiana Mrs. Bambi Gardner, St. John, Indiana
9:30 a.m.–10 a.m.	**PANEL 2: Grade Crossing Collision Experiences** Mr. Doug Manson, Train Engineer, Amtrak Mr. Billy Parker, Train Engineer, Amtrak
10 a.m.–10:15 a.m.	**Break**
10:15 a.m.–11:30 a.m.	**PANEL 3: Passive Grade Crossing Concerns** Mr. Carmen Bianco, Assistant Vice President of Safety, Amtrak Mr. Achille Ferrusi, Assistant Vice President, Canadian National North America Ms. Anya Carroll, Principal Investigator, Transportation Systems Center Captain Clarence Greeno, Missouri State Highway Patrol
11:30 a.m.–1 p.m.	**Lunch**

1 p.m.–2 p.m. **PANEL 4: Grade Crossing Study Through Education and the Media**
Mr. Ross Simpson, NBC Mutual Radio
Mrs. Gerri Hall, President, Operation Lifesaver, Inc.
Ms. Nathalie Herbst, Florida Operation Lifesaver/AAA

2 p.m.–2:45 p.m. **PANEL 5: Physical Characteristics of Passive Grade Crossings**
Dr. Gary Long, Transportation Engineering Coordinator, University of Florida
Dr. Stephen Richards, Director, Transportation Center, University of Tennessee
Dr. Gene Russell, Director, Center for Transportation Research and Training, Kansas State University
Mr. Hoy Richards, President, Richards & Associates, Inc., College Station, Texas
Dr. David Lipscomb, President, Correct Services, Stanwood, Washington

2:45 p.m.–3 p.m. **Break**

3 p.m.–4 p.m. **PANEL 5 (continued)**

Friday, May 9, 1997

8:30 a.m.–10 a.m. **PANEL 6: Communications Between Railroad and Highway Officials**
Ms. Lucy Amerman, Vice President, Consolidated Rail Corporation
Mr. Marty Fiorentino, Vice President, CSX Transportation, Inc.
Mr. Otto Sonefeld, Program Director, American Association of State Highway and Transportation Officials
Mr. Star L. Rheynard, P.E., National Association of County Engineers, Mercer County, Illinois

10 a.m.–10:15 a.m. **Break**

10:15 a.m.–Noon	**PANEL 7: Crossing Closures and Private/Public Crossings** Mr. Cliff Shoemaker, Director, Industry and Public Projects, Union Pacific Railroad Mr. Danny Gilbert, Manager, Grade Crossing Safety, Norfolk Southern Railroad Mr. Richard T. Mooney, Manager, Railroad Safety, State of Missouri Mr. Hoy Richards, President, Richards & Associates, Inc., College Station, Texas
Noon–1:30 p.m.	**Lunch**
1:30 p.m.–3 p.m.	**PANEL 8: Responsibility for Grade Crossing Safety** Mr. Bruce George, Staff Director, Highway-Rail Crossing and Trespasser Division, Federal Railroad Administration Mr. Fred Small, Acting Chief, Safety Management and Policy Division, Federal Highway Administration Mr. Bill Browder, Director of Operations, Association of American Railroads Mr. Otto Sonefeld, Program Director, American Association of State Highway and Transportation Officials
3 p.m.	**CLOSING REMARKS:** The Honorable Robert Francis, Vice Chairman, National Transportation Safety Board

Appendix E

Data From the NTSB Study Sample

Table E–1. National Transportation Safety Board accident numbers, dates, and locations for the 60 study accidents.

Case number[a]	NTSB accident number	Accident date	Accident location
01	SRH96FHX01	01/10/96	Childersburg, AL
03	CRH96FHX03	02/04/96	Duson, LA
04	WRH96FHX05	02/08/96	Magnolia, TX
05	CRH96FHX04	02/28/96	Millsap, TX
06	WRH96FHX06	03/05/96	Bernalillo, NM
07	SRH96FHX03	03/08/96	Fort Payne, AL
08	SRH96FHX05	03/12/96	Doraville, GA
09	SRH96FHX06	03/18/96	Theodore, AL
10	ATL96FRX13	03/09/96	Murfreesboro, TN
11	ATL96FRX05	12/14/95	Ponchatoula, LA
12	CRH96FHX05	03/19/96	Robstown, TX
13	LAX96FRX08	03/25/96	Luxora, AR
14	NRH96FHX05	03/15/96	Waxahachie, TX
15	NRH96FHX06	03/20/96	Clairton, PA
16	CRH96FHX06	04/05/96	Calhoun, LA
17	LAX96FRX09	03/27/96	Jonesboro, AR
18	SRH96FHX07	04/19/96	Avinger, TX
19	SRH96FHX08	04/21/96	Strafford, MO
20	SRH96FHX10	05/03/96	Alton, LA
21	SRH96FHX09	05/03/96	Saraland, AL
22	CRH96FHX07	04/13/96	Bristow, OK
23	CHI96FRX12	04/24/96	Bettendorf, IA
25	ATL96FRX14	05/09/96	Greenway, AR
26	CRH96FHX08	05/01/96	Bonita, LA
27	WRH96FHX07	05/27/96	Tickfaw, LA
28	WRH96FHX08	05/28/96	Walls, MS
29	SRH96FHX11	05/29/96	Lula, GA
30	WRH96FHX09	05/29/96	Seward, OK
31	WRH96FHX10	06/02/96	Greenwood, MS
32	WRH96FHX11	04/29/96	Ada, OK
33	CRH96FHX09	06/03/96	Trumann, AR
34	ATL96FRX16	05/22/96	Texarkana, AR
35	ATL96FRX17	05/28/96	Rayville, LA
36	CHI96FRX16	05/29/96	Racine, MO
37	CHI96FRX17	05/30/96	Montrose, IL
38	CRH96FHX10	06/24/96	Como, TX
39	LAX96FRX12	06/19/96	San Jose, CA
40	NRH96FHX11	06/21/96	St. Albans, VT
41	CHI96FRX18	06/21/96	Pickerington, OH
42	SRH96FHX13	07/15/96	Jasper, AL

(continued)

Table E–1. National Transportation Safety Board accident numbers, dates, and locations for the 60 study accidents.

Case number[a]	NTSB accident number	Accident date	Accident location
(continued)			
43	WRH96FHX12	07/15/96	Floyd, TX
44	CHI96FRX20	07/09/96	Cromwell, IN
45	NRH96FHX12	07/24/96	Rosedale, MD
46	SRH96FHX16	08/06/96	Bryan, TX
47	ATL96FRX21	08/03/96	Simpson, NC
48	SRH96FHX17	08/13/96	Austin, TX
49	SRH96FHX18	08/17/96	Hazelhurst, GA
50	SRH96FHX19	08/18/96	Cuba, MO
51	CHI96FRX21	07/20/96	Pass Christian, MS
52	CHI96FRX22	08/13/96	Knob Noster, MO
53	CRH96FHX12	08/13/96	Poteau, OK
54	SRH96FHX20	08/21/96	Napton, MO
55	NRH96FHX13	08/27/96	Roxbury, VT
56	ATL96FRX25	07/30/96	Perry Township, OH
57	ATL96FRX23	08/12/96	Bennettsville, SC
58	ATL96FRX24	08/12/96	Columbus, OH
59	SRH96FHX22	08/26/96	Hawthorne, FL
60	WRH96FHX15	08/27/96	Los Molinos, CA
61	CRH96FHX13	08/23/96	Brownsboro, TX
62	LAX96FRX13	08/23/96	Naponee, NE

[a] Cases 02 and 24 were determined not to meet the qualification criteria for the study; therefore, they were excluded from the analyses.

Table E–2. Sight distances required by the driver of a highway vehicle approaching the 60 grade crossings involved in the study accidents and the sight distances available.[a]

In feet

Case number[b]	Along the roadway[c]: Required sight distance	Along the roadway[c]: Actual sight distance	Along the roadway[c]: Shortfall in available site distance	Along the tracks[d]: Required sight distance	Along the tracks[d]: Actual sight distance	Along the tracks[d]: Shortfall in available site distance
01	271	175	-96	467	300	-167
03	219	211	-8	582	550	-32
04	128	128		473	473	
05	570	546	-24	392	376	-16
06	67	67		786	786	
07	281	86	-185	516	156	-360
08	334	255	-79	92	69	-23
09	342	80	-262	789	184	-605
10	69	69		618	618	
11	164	164		603	603	
12	578	511	-67	656	574	-82
13	172	172		451	451	
14	404	213	-191	334	178	-156
15	45	45		140	140	
16	271	72	-199	422	112	-310
17	94	94		483	483	
18	173	61	-112	396	143	-253
19	94	94		484	484	
20	170	81	-89	397	198	-199
21	129	84	-45	387	252	-135
22	753	144	-609	585	187	-398
23	65	65		407	407	
25	NA	NA		NA	NA	
26	758	758		616	616	
27	167	57	-110	620	501	-119
28	404	404		762	762	
29	94	94		542	542	
30	127	53	-74	421	178	-243
31	404	194	-210	672	324	-348
32	179	76	-103	443	150	-293
33	565	260	-305	498	296	-202
34	271	43	-228	425	67	-358
35	168	168		381	381	
36	660	423	-237	691	58	-633
37	564	564		537	537	
38	70	57	-13	508	406	-102
39	165	165		594	594	
40	NA	NA		NA	NA	
41	132	132		330	330	
42	129	40	-89	389	121	-268
43	567	567		539	539	
44	574	167	-407	661	192	-469
45	173	101	-72	524	293	-231
46	111	28	-82	257	65	-192
47	251	39	-212	416	65	-351

(continued)

Table E–2. Sight distances required by the driver of a highway vehicle approaching the 60 grade crossings involved in the study accidents and the sight distances available.[(a)]

In feet

	Along the roadway[(c)]			Along the tracks[(d)]		
Case number[(b)]	Required sight distance	Actual sight distance	Shortfall in available site distance	Required sight distance	Actual sight distance	Shortfall in available site distance
(continued)						
48	94	94		363	363	
49	129	31	-98	391	96	-295
50	96	96		473	473	
51	77	51	-26	375	245	-130
52	65	33	-32	704	359	-345
53	170	170		361	361	
54	94	94		363	363	
55	173	173		584	584	
56	NA	NA		NA	NA	
57	408	408		254	254	
58	70	70		145	145	
59	94	45	-49	542	264	-278
60	65	54	-11	656	536	120
61	657	29	-628	685	28	-657
62	216	156	-60	243	168	-75

NA = not available.

[(a)] Sight distances are the distances along the roadway and along the railroad tracks needed by a motorist to detect the presence of a train in time to stop. Distances in this table have been rounded to the nearest foot. To calculate the sight distances, the Safety Board used the guidelines recommended by the American Association of State Highway and Transportation Officials (AASHTO) in *A Policy on Geometric Design of Highway and Streets* published in 1990. For purposes of this study, however, the Board assumed the design vehicle to be the highway vehicle involved in the study case accident. A highway engineer reviewed the formulas used to calculate the sight distances.

[(b)] Cases 02 and 24 were excluded from the analyses because they were determined not to meet the qualification criteria for the study.

[(c)] The distance from the highway vehicle approaching the grade crossing to the grade crossing.

[(d)] The distance from the grade crossing to the oncoming train.

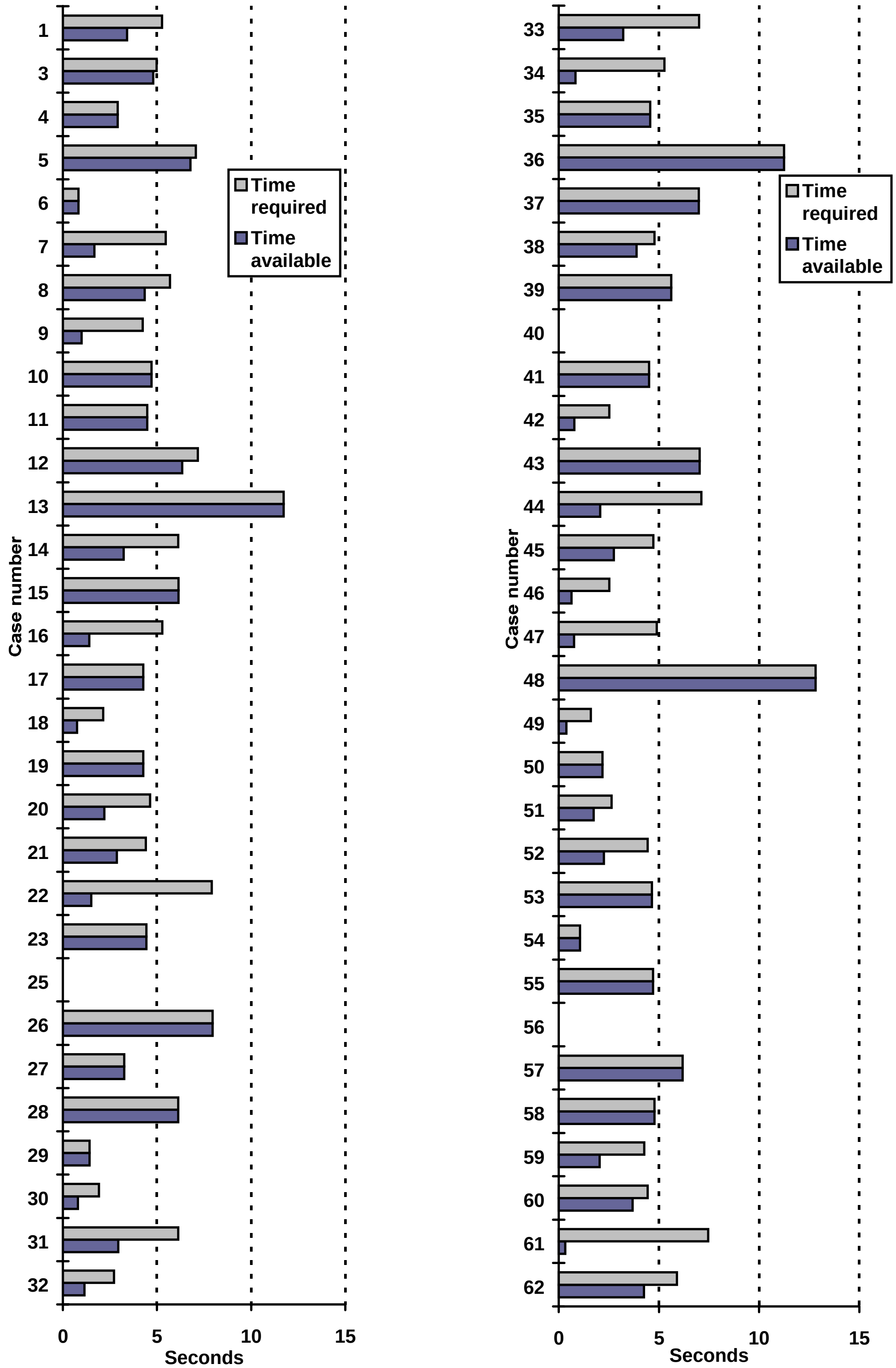


Figure E–1. Safe stopping time needed by highway vehicles approaching the passive grade crossings in the study cases compared with the stopping time available given the sight distance along the roadway. (Data were not available for the crossings in cases 25, 40, and 56.)

Table E–3. Ages of the highway vehicle drivers involved in the 60 study accidents.

Age	Number of male drivers	Percent of male drivers	Number of females	Percent of female drivers
Under 20	3	6.82	0	0.00
20-29	11	25.00	3	18.75
30-39	7	15.91	7	43.75
40-49	8	18.18	2	12.50
50-59	8	18.18	2	12.50
Over 60	7	15.91	2	12.50
Total	44	100.00	16	100.00

Table E–4. Number of traffic violations accrued by the 24 accident-involved drivers who had violations in their driving history for the 3-year period prior to the study accident.[a]

Violation	Number of convictions or incidents	Percent of the total number of convictions or incidents[b]
Speeding	20	33.3
Accident	7	11.6
Driving under the influence	3	5.0
Other	12	20.0
Total	42	100.0

[a] Of the 60 drivers involved in the study case accidents, 36 (60 percent) had no driving convictions in their driving history for the previous 3 years. Driving histories were not available for 2 of those 36 drivers because neither driver had ever held a driver's license in any State.

[b] A driver might have had more than one conviction.

Table E–5. Prior accident experience of the train engineers involved in the 60 study accidents.[a]

Type of accident	Number of engineers[b]	Number of accidents[c]
Train struck highway vehicle	36	141
Train derailed	17	37
Highway vehicle struck train	13	22
Train collided with another train	2	2
Other	5	13

[a] This information was not available for the engineers involved in cases 21, 38, 45, and 58. The engineers in cases 23, 41, and 42 reported no previous accident experience.

[b] Some engineers had experienced more than one type of accident.

[c] Some engineers had experienced more than one accident of a given type.

Table E–6. Number of private passive highway-rail grade crossings in the Federal Railroad Administration inventory by type of development in the vicinity of the crossing, 1996.

Type of development	Number of crossings	Percent of private passive crossings
Farm	62,942	60.94
Residential	12,037	11.65
Recreational	1,605	1.55
Industrial	24,374	23.60
Unknown	2,337	2.26
All types	103,295	100.00

Table E–7. Types of highway vehicles and trains involved in the accidents at the 60 study accident crossings.

Type	Number of cases
Highway vehicle:	
Passenger car	26
Light truck	22
Tractor semi-trailer	8
Single unit truck	1
Step van	1
School bus	1
Other	1
Train:	
Through freight	39
Passenger	11
Local freight	6
Work train	2
Commuter	1
Light locomotive	1

Table E–8. Action of the highway vehicle driver prior to the grade crossing accident.

Driver's pre-crash action	Number of cases	Case number
Proceeded without stopping or slowing	19	1, 4, 6, 8[(a)], 10, 12, 21, 23, 31, 34, 35, 36, 42, 45, 47, 50, 55, 57[(a)], 62
Slowed, then proceeded or accelerated	16	7, 15, 16, 18, 19, 20, 22, 32[(b)], 37[(a)], 38, 40, 46, 49, 56, 58, 59
Stopped, then proceeded	10	5, 13, 17, 26[(c)], 27, 29, 39, 44, 53, 61
Lodged or stalled on tracks	4	25, 48, 52, 54
Stopped on tracks	5	11, 28, 33, 41, 60
Other	4	3[(c)], 14, 43[(a)], 51
Unknown	2	9, 30

(a) The highway vehicle struck the train.

(b) The highway vehicle reportedly stopped on the tracks, backed away, then accelerated forward.

(c) The vehicle was described as backing off the tracks.

Table E–9. Number of the 60 study accidents by weather condition and road condition.

Weather condition	Number of accidents	Road surface condition	Number of accidents
Overcast	14	Wet	4
Rain	2	Snow/slush	0
Snow	0	Ice	0
Sleet	0	Sand/dirt/oil	0
Hail	0	Other	0
Haze	0	Dry	56
Fog	0		
Clear	44		

Table E–10. Crossing surface material at the 60 study accident crossings.

Crossing surface material	Number of crossings where present
Sectional timber	27
Asphalt	23
Full wood plank	6
Rubber slab	2
Concrete slab	1
Unconsolidated	1

Appendix F

Supplemental Investigation on Train Horn Audibility

In December 1996, the Safety Board, in cooperation with Oklahoma Operation Lifesaver, the Oklahoma Department of Transportation, and Burlington Northern Santa Fe Railroad, conducted tests in Oklahoma City, Oklahoma, to determine the audibility of a train horn within 13 different passenger and emergency vehicles representing the current generation of highway vehicles. Testing was conducted according to the specifications established in American National Standard S12.18–1994,[1] using a Bruel & Kaer audiometer type 2232, a sound level calibrator type 4230, and a 1-inch wind screen. The test horn, a three-chime Leslie horn, was mounted on a locomotive positioned 100 feet from the test vehicles, and had a sound level of 96 dB(A)[2] at 100 feet from the source, as required by the FRA's regulations. The Safety Board measured (1) the insertion loss for each highway vehicle,[3] (2) the audibility of the train horn with the highway vehicle engine idling, and (3) the audibility of the train horn with the highway vehicle engine idling and the air conditioning fan on the "high" setting. Testing showed a maximum insertion loss of 33 dB, in a 1986 Chevrolet Corvette, and a minimum insertion loss of 17 dB, in a 1986 Freightliner cab-over tractor (table F–1).

Safety Board measurements determined that in one test vehicle (a 1997 Thomas/Ford school bus) the sound level of the train horn was not audible above the noise level of the idling engine. In seven test vehicles, the sound level was not audible above the idling engine and fan noise. In no test vehicle that had both the engine idling and the fan operating did the train horn provide the 10 dB above ambient noise level necessary to "alert" a motorist to the train (table F–2). Because the ambient noise levels within a highway vehicle increase with additional noise from sources such as road surface texture, radio use, environment and conversations within the vehicle, the levels in the Safety Board's tests are an underestimation of the interior noise levels that occur in everyday driving.

[1] Acoustical Society of America. 1994. Procedures for outdoor measurement of sound pressure level. American National Standard ANSI S12.18-1994. New York, NY: American National Standards Institute. 18 p.

[2] There are different scales by which to measure sound levels; "(A)" denotes the decibel scale by which human hearing is measured. As used in the report and in this appendix, the levels are assumed to be measured by this scale.

[3] Insertion loss is the difference between the measured values of a sound from an exterior sound source taken outside the highway vehicle and inside the vehicle.

Table F–1. Insertion loss from vehicle shell of current generation highway vehicles.[a]

Highway vehicle	Insertion loss (decibels)
1986 Freightliner cab-over truck-tractor	17
1996 Freightliner conventional truck-tractor	18
1996 Thomas/International school bus	21
American La France fire truck	21
1994 Dodge Ram 1500 pickup truck	26
1990 Ford F-350 ambulance	27
1997 Thomas/Ford school bus	27
1978 TMC Crusader coach bus	28
1991 Chevrolet Lumina	28
1996 Ford F-250 diesel pickup truck	28
1987 Mercedes 300 SDL turbo	29
1995 Oldsmobile Achieva	32
1986 Chevrolet Corvette	33

[a] Insertion loss is the difference between the measured values of a sound from an exterior sound source taken outside the highway vehicle and inside the vehicle.

Table F–2. Noise level of a 96-decibel train horn measured in the interior of current generation highway vehicles 100 feet from the train horn.

In decibels

Highway vehicle	In vehicle interior with windows closed	In vehicle interior with windows closed and engine idling	In vehicle interior with windows closed, engine idling, and fan running
1986 Freightliner cab-over truck-tractor	79	10	8
1996 Freightliner conventional truck-tractor	78	12	7
1996 Thomas/International school bus	75	11	-2
American La France fire truck	75	5	0
1994 Dodge Ram 1500 pickup truck	70	25	4
1990 Ford F-350 ambulance	69	8	4
1997 Thomas/Ford school bus	69	-2	-11
1978 TMC Crusader coach bus	68	8	-1
1991 Chevrolet Lumina	68	21	1
1996 Ford F-250 diesel pickup truck	68	12	2
1987 Mercedes 300 SDL turbo	67	14	0
1995 Oldsmobile Achieva	64	17	-2
1986 Chevrolet Corvette	63	1	-3