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I-108A

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

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In reply refer to: H-98-28 through -33,
and I-98-1 and -2

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Secretary
U.S. Department of Transportation
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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 (FRA), 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 a 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 [1]

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.

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.

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 shown in the Safety Board's study, 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 shown in the Board's study, 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. The accident sample in the Safety Board's study illustrates that this approach has been inadequate in many instances.

[1] National Transportation Safety Board. 1998. Safety at passive grade crossings. Volume 1: Analysis. Safety Study NTSB/SS-98/02. Washington, DC.

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. This letter addresses several of these 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. 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.[2] 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

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.[3] 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.

[2] 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.

[3] 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 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.

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 Federal Highway Administration's (FHWA) *Railroad–Highway Grade Crossing Handbook* and the American Association of State Highway and Transportation Officials' (AASHTO) *A Policy on Geometric Design of Highways and Streets* (the 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 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. The Safety Board is recommending, therefore, that the States 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.[4] 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.

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.[5] 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.[6] 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 U.S. Department of Transportation (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.

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.

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.[7]

A report on rail–highway 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

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[4] 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.

[5] 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).

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

[7] 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.

a crossing, are so generally disregarded that they are not effective and create disrespect for warnings generally."[8] 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.[9]

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.[10] 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

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[8] 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).

[9] 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.]

[10] 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.]

5. The rail line is regularly used to transport a significant quantity of hazardous materials.

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."[11] 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.[12] Another study reported that for familiar crossings, stopping compliance can be as low as 29 percent.[13] 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

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

[12] 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.]

[13] 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.

distance.[14] This is 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 in AASHTO's Greenbook.

Another concern raised about stop signs 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. 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.

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.[15] 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.[16]

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

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[14] 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).

[15] 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).

[16] (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.

what action must be taken. Further, the presence of a stop ahead sign, required by the FHWA's *Manual on Uniform Traffic Control Devices* (MUTCD) before a stop sign at a grade crossing, warns the driver in advance of what action is 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. 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; and 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 traffic 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. 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 is recommending that 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.

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 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.[17] 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.

Enforcement Activities at Crossings

According to the Association of American Railroads (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."[18]

The 1994 DOT Action Plan developed by the four modal administrations outlined several initiatives to increase enforcement of traffic laws at crossings. One initiative involved the use of Section 402[19] funds to promote targeted public education, and engineering and law enforcement strategies. The National Highway Traffic Safety Administration (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 developed 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.

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

[18] 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.

[19] 23 U.S.C. §402 authorizes the Secretary of the DOT to approve and provide funding for certain State highway safety programs.

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 comments.[20]

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.[21] 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.[22] 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

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

[21] 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)

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

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 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."[23] 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.[24] 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.[25] The American Automobile Association (AAA) has been involved in driver education since the mid-1930s. The AAA writes and provides driver education materials 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.[26]

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[23] 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.

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

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

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

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 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 examinations 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.[27] 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 examination tests. The Safety Board is recommending, therefore, that the States ensure that questions on safety at passive grade crossings are included in every version of a State's written driver examination. Further, the Safety Board is recommending 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.

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 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

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

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.[28]

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.[29] 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.

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. 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.

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[28] 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.)

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

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.[30] 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.[31] 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.[32] One proposed solution being tested by the Burlington Northern Santa Fe and the Union 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.[33] 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

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

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

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

[33] 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).

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.[34]

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.[35] At the time the Board prepared its report of the current safety study, 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.[36] 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 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

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

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

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

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.[37] In fact, it has not yet been determined which standards need to be developed,[38] 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.

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, 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.[39]

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

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

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

[39] 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.

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.

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.[40]

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.[41] Despite this, the overall national result is that responsibilities are most often undefined or are inconsistently acknowledged and applied.
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> 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 [*Manual on Uniform Traffic Control Devices*] 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

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

[41] 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.

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. Therefore, the Safety Board believes that the DOT should 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 MUTCD.

Therefore, the National Transportation Safety Board recommends that the 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)

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

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

By: Jim Hall
Chairman