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Survey of Driver Perceptions of Railroad and Light Rail Warning Devices/Grade Crossings

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16. Abstract

The objective of this study is to conduct a human factors survey to understand drivers' behavior and perceptions at various types of railroad and light rail crossings, and determine their understanding of different types of traffic control devices. This understanding would help to take necessary steps to improve the safety of railroad and light rail crossings, and also determine the appropriate information that should be included in the driver manuals. A human factors experiment was conducted which studied 38 subjects about their perceptions and decision makings while a car traveled approaching railroad crossings. Results of the study suggest that some traffic control devices used in the vicinity of railroad grade crossings, such as stop sign and traffic signal lights, should be implemented carefully to avoid confusion to drivers. Many drivers are not familiar with traffic control devices or roadway layout at light rail crossings. A proposed section to address driving issues related to railroad crossing was drafted based on the experiment results, literature review, and comparison of other states' driver manuals. A simulated driver test was conducted using questions constructed based on information in the 2004 New Jersey Driver Manual and the proposed railroad crossing section. Human factors research methodology has demonstrated to be an effective approach for studying driver perception and driving behaviors on the current traffic safety project.

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SUMMARY

The overall objective of this study is to conduct a human factors survey to understand drivers' and pedestrians' behavior and perceptions at various types of railroad and light rail crossings, and determine their understanding of different types of traffic control devices. This understanding can help the Diagnostic Team at New Jersey Department of Transportation to take necessary steps to improve the safety of railroad and light rail crossings, and also determine the appropriate information that should be included in the driver manuals.

The specific objectives of this study are to:

- Determine drivers' (auto, truck, hazmat carrier, school bus, commercial bus, etc.) and pedestrians' behavior and perceptions at the various types of railroad and light rail grade crossings.

- Determine drivers' (auto, truck, hazmat carrier, school bus, commercial bus, etc.) and pedestrians' understanding of the various active and passive railroad warning devices at the public railroad and light rail grade crossings in New Jersey.

- Determine what information should be included in the New Jersey Driver Manual, Commercial Driver Manual, Motorcycle Driver Manual, and Motorized Bicycle Driver Manual on Railroad and light rail lines.

- Recommend and test appropriate questions that should be included in the written Driver and Commercial Drivers exams to insure that all understand the various active and passive railroad and light rail warning devices at New Jersey's 1600 crossings.

Results of the study suggest that some traffic control devices used in the vicinity of railroad grade crossings, such as stop sign and traffic signal lights, should be implemented carefully to avoid confusion to drivers. Many drivers are not familiar with traffic control devices or roadway layout at light rail crossings. Human factors research methodology is an effective approach of studying driver perception and driving behaviors for the current traffic safety project.

INTRODUCTION

Every year hundreds of people die in railroad vehicle crashes. Some crashes happen because drivers do not perceive the danger. Others happen due to reckless driving. Major safety efforts in this century have been directed to increase the safety of railroad grade crossing, with significant success. According to the results presented in the Railroad-Highway Grade Crossing Handbook [(1)], the number of fatalities involving motor vehicles in railroad crossings has decreased from approximately 2000 per year in the late 1920's to approximately 500 per year by the mid 1980's. In addition, from 1992-1997, railroad grade crossing incidents fell by 20 percent and related fatalities by 17 percent; nonetheless, there remained 419 fatalities and nearly 1500 injuries [(2)]. Although fatalities have been coming down, with increasing number of high-speed trains and increase in traffic volumes, the resulting increase in potential for train/vehicle collisions must be offset by continued improvements in the railroad crossing environment.

Eliminating grade crossings by creating overpasses is one way to eliminate train/vehicle collisions. However, it is very expensive to do this: one study estimates that the cost could be as much as $ 5 million per crossing [(3)]. Some states have started experimenting with new technology, e.g., Florida will be testing rail crossing warning system that will provide grade crossing status information and alerts to approaching locomotives [(4)]. New York is experimenting with video cameras on their trains to warn train operators of vehicles that are stuck on the tracks [(3)]. Reilly et al. [(5)] have proposed video detection technology for real-time detection of the presence of vehicles and railroad crossings.

Use of new technology is important. However, in order to have a continued reduction in the number of train/ vehicle crashes, there is a need for better understanding of driver behavior and perceptions at different types of railroad and light rail crossings. A study of railroad crossings by the National Transportation Safety Board [(6)] concluded that the standard signs mandated by the Manual of Uniform Traffic Control Devices fail to communicate to the driver what action is needed at a crossing. Another study found that many drivers do not fully understand what is required of them when they encounter a flashing light signal at a railroad crossing [(7)]. To understand driver behavior at different types of crossings, it is necessary to conduct a human factors survey of driver behavior and perceptions. Driver behavior is dependent on the background of the driver and can vary between different parts of the country. This survey would help in the design and installation of appropriate traffic control devices and find better ways of educating the driving population about the possible hazards. An important component of driver education is to ensure that appropriate information is included in the driver manuals and appropriate questions are included in the written driver's exams. A review of selected pages of New Jersey Driver Manual indicates that the manual does not provide a comprehensive coverage of the topic in a user-friendly manner.

Literature Review

One objective of this review was to assess what other studies have found in terms of driver perceptions and behavior at different types of crossings. Sources which included refereed journals, conference proceedings, and published technical reports was identified through a search in TRIS[1], TRANSPORT[2], and the Internet. The Transportation Research Information Services (TRIS) bibliographic database was used to identify relevant documents for obtaining this information. The TRIS database includes over 400,000 records covering transportation research published in books, journal articles, and technical reports published by federal, state and local agencies. The Dowling College and NJIT libraries use state-of-the-art computerized searches to identify relevant documents. State Department of Transportation libraries will also be contacted to identify additional reports not included in these databases.

A review of the literature revealed a wide body of literature exists on railroad/light rail crossings. A more detailed literature review is included in Appendix A. Some studies have conducted surveys to study driver perceptions at railroad crossings and to understand why drivers commit violations (8). A few studies have conducted laboratory experiments to study driver perceptions and performance associated with traffic control devices (9). Others have conducted field studies to observe drive behavior and to study the effectiveness of new traffic control devices (10, 11). Following is a summary of the literature review. The results are discussed for passive and active crossings separately.

Passive Crossings

These crossings consist of a crossbuck sign, advance warning signs, and pavement markings consisting of an X and letters RR. In passive crossings, it is the responsibility of the driver to look for trains and cross the tracks only when it is safe to do so. Passive crossings usually exist in rural areas where there is limited traffic volume.

Crashes at passive crossings happen for many reasons including the following:

1. Sometimes the driver is not aware of the train's arrival either because of lack of sufficient sight distance or limited conspicuity of the sign / train. Due to the geometry and the lack of availability of right of way, sight distance problems are sometimes difficult to correct. One study has attempted to address this problem by changing the crossing into an active crossing and introducing flashing beacons with standard advance warning signs at sufficient distance before the crossing (12). Some states have used non-standard signs to deal with this unusual situation (13). To deal

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[1] TRIS – transportation research information service
[2] TRANSPORT is a database that includes TRIS and list of references from Europe, Australia, and New Zealand

with conspicuity problems, researchers have proposed modifications to the reflectivity of the sign [(14)]. Zwahlen and Schnell [(10, 11)], improved the reflectivity of the sign, and found that this improved the visibility and conspicuity of the crossbuck sign. Recently, there has been some work on the use of auxiliary external alerting devices to improve locomotive conspicuity [(15)].

2. Some drivers do not know the required response to a crossbuck [(6)]. Several studies have proposed additions to the crossbuck. Some have proposed an inverted triangle that is similar to the standard yield sign [(14)]. Others have tested a 'LOOK FOR TRAIN AT CROSSING' sign and a vehicle activated flashing strobe light in addition to the standard crossbuck [(16)]. Zwahlen and Schnell [(10, 11)], conducted a field study by introducing an 'YIELD' sign. NTSB [(6)] has recommended the addition of the stop sign at all passive crossings, unless an engineering study finds that a stop sign would decrease safety for a particular site. In addition to the necessary changes to the crossbuck design, driver education efforts are necessary to ensure that drivers understand the meaning of these signs and know what is expected under these situations. One way to address this issue is to ensure that the driver manual has a clear and comprehensive discussion of this topic.

3. In some cases, the driver may detect the train but incorrectly decide that sufficient time was available [(16)]. This is a difficult problem and could be addressed through intensive driver education efforts such as Operation Lifesaver and better enforcement [(17)].

Active Crossings

Active crossings consist of a crossbuck sign along with flashing lights, bells, and / or gate controls. Some of the reasons for crashes at active crossings are the same as those at passive crossings, others occur due to driver impatience and confusion. For example, some drivers do not fully understand what is required of them at a flashing light signal especially if there are no gates [(7)]. Lack of sufficient sight distance is also a problem in some active railroad crossings.

One problem with active crossings is that some drivers willfully violate the traffic control device. Abraham et al. [(7)] mailed questionnaires to people who violated an active traffic control device to understand the reasons for their behavior. Many respondents stated that they violated the traffic law because the 'train was not is sight' or the train 'was stopped to an unreasonable amount of time'. One reason for this behavior is that some crossings are designed to provide warning times[3] based on the fastest train that will go through the crossing. Hence, if a slow train goes through the crossing, the waiting time can be excessively long.

[3] Warning time is the duration between the activation of a control device at a crossing and the arrival of the train

One study of 6 crossings found that warning times ranged from 20 seconds to 16 minutes [18]. Richards and Heathington [9] in their laboratory study found that "most drivers expect a train to arrive within 20 seconds from the moment when the traffic control devices are activated, and begin to lose confidence in the traffic control system if the warning time exceeds 40 seconds at crossings with flashing light signals and 60 seconds at gated crossings". Due to this, some researchers have proposed and tested constant warning time systems and found them to be effective in reducing the number of violations [19, 20]. In some cases, crashes happen because drivers don't understand that another train may be coming from the opposite direction after the first train passes the crossing [7].

To eliminate violations at gated crossings, Heathington et al. [21] tested four-quadrant gates and found them to very effective. The study also recommended that four-quadrant gates should not be used on routes that are frequented by emergency vehicles. Other studies have proposed the use of median barriers to prevent drivers from driving around standard two-quadrant gates.

Heathington et al. [21] also tested standard traffic signals at active grade crossings and found them to be better than flashing lights without gates. However, most active crossings these days still use flashing lights.

Crashes also happen due to driver confusion at railroad crossings that are close to intersections. In some cases, drivers have been found to turn onto the railway tracks instead of the road that is parallel to the tracks. Sometimes vehicles get stuck at railroad crossings because the traffic signal at the adjacent intersection forces queues to spillover onto the tracks [22].

METHODS

This project involves human factors research methods for studying drivers' perception and design of draft railroad section for New Jersey driver's manuals. A laboratory experiment was conducted for studying driver perception and decision making on railroad crossing related issues. A draft railroad crossing section for New Jersey driver manuals was developed based on literature review, comparison of other states' driver manuals, and results from the human factor experiment. A simulated driver test was conducted using questions constructed based on information in the 2004 New Jersey Driver Manual and the proposed railroad crossing section.

Experiment I: Driving Perception and Behavior

The purpose of the experiment is to investigate driver's responses on driving conditions of approaching and passing railroad grade crossings. Video recordings were taken from a moving vehicle traveling through railroad crossings at various locations, conditions and time in New Jersey cities. The research team visited various types of railroad grade crossings in central New Jersey, including Morristown, Hackensack, Jersey City, and North Brunswick (see Figure 1, 2, 3). The entire experiment was controlled by a computer, including the randomized sequence of video clips, questions after each video clip, and data recording of subject responses. Subjects with New Jersey driver licenses were tested on their judgment while viewing short video clips displayed on a large screen. The responses were recorded directly into a computer for subsequent data analyses.

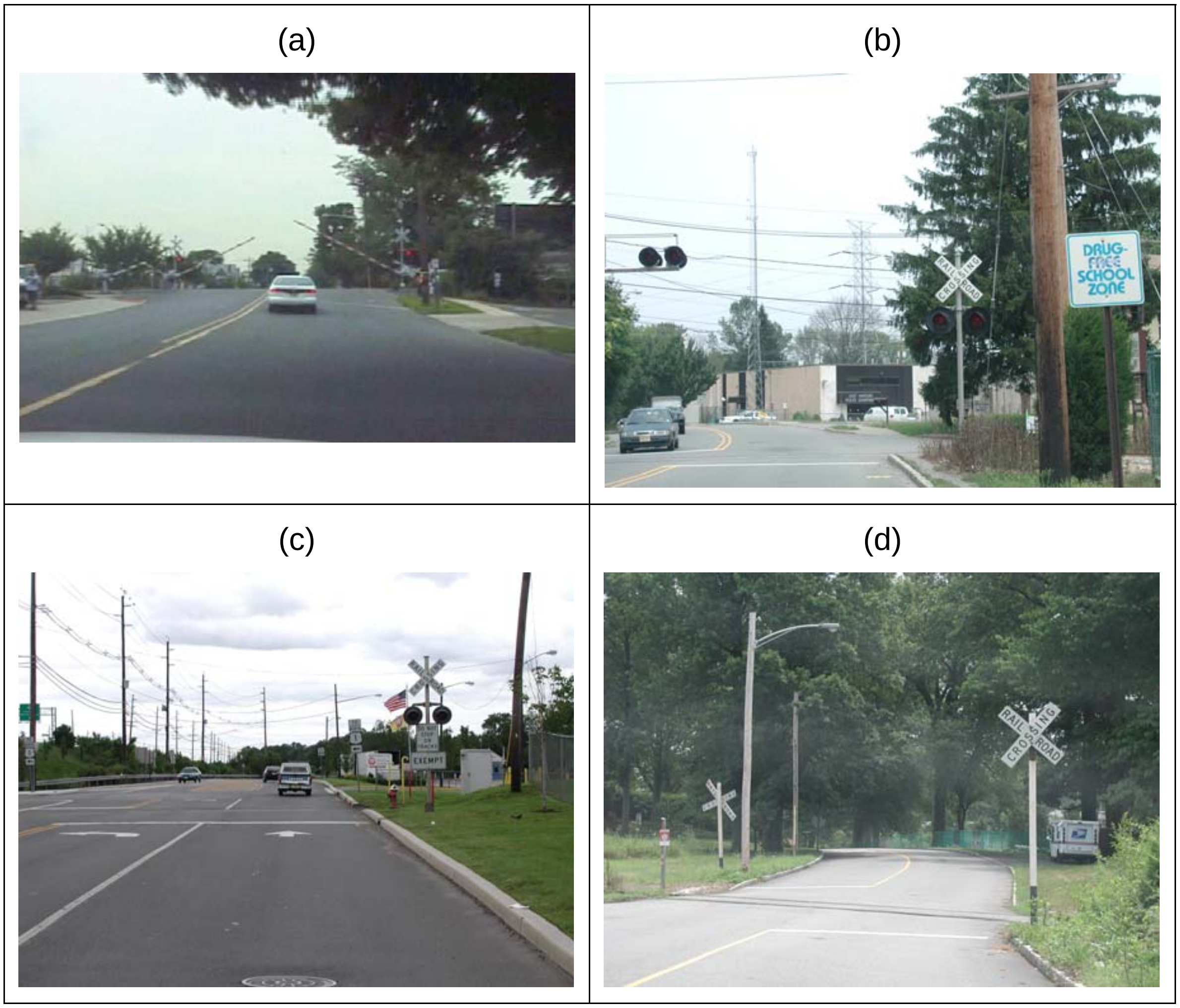


Figure 1. Railroad crossings equipped with different traffic control devices:
(a) with two-quadrant gates, (b) with flashing red lights and crossbuck sign,
(c) same as (b) with additional signs, (d) with only crossbuck sign.

(a)

(b)

(c)

(d)

Figure 2. Railroad crossings equipped with different traffic control devices:
(a) crossing paint at night, (b) with flashing red lights and traffic signal lights,
(c) Stop sign and other control devices , (d) crossbuck sign and stop sign close to each other for railroad crossing and roadway intersection.

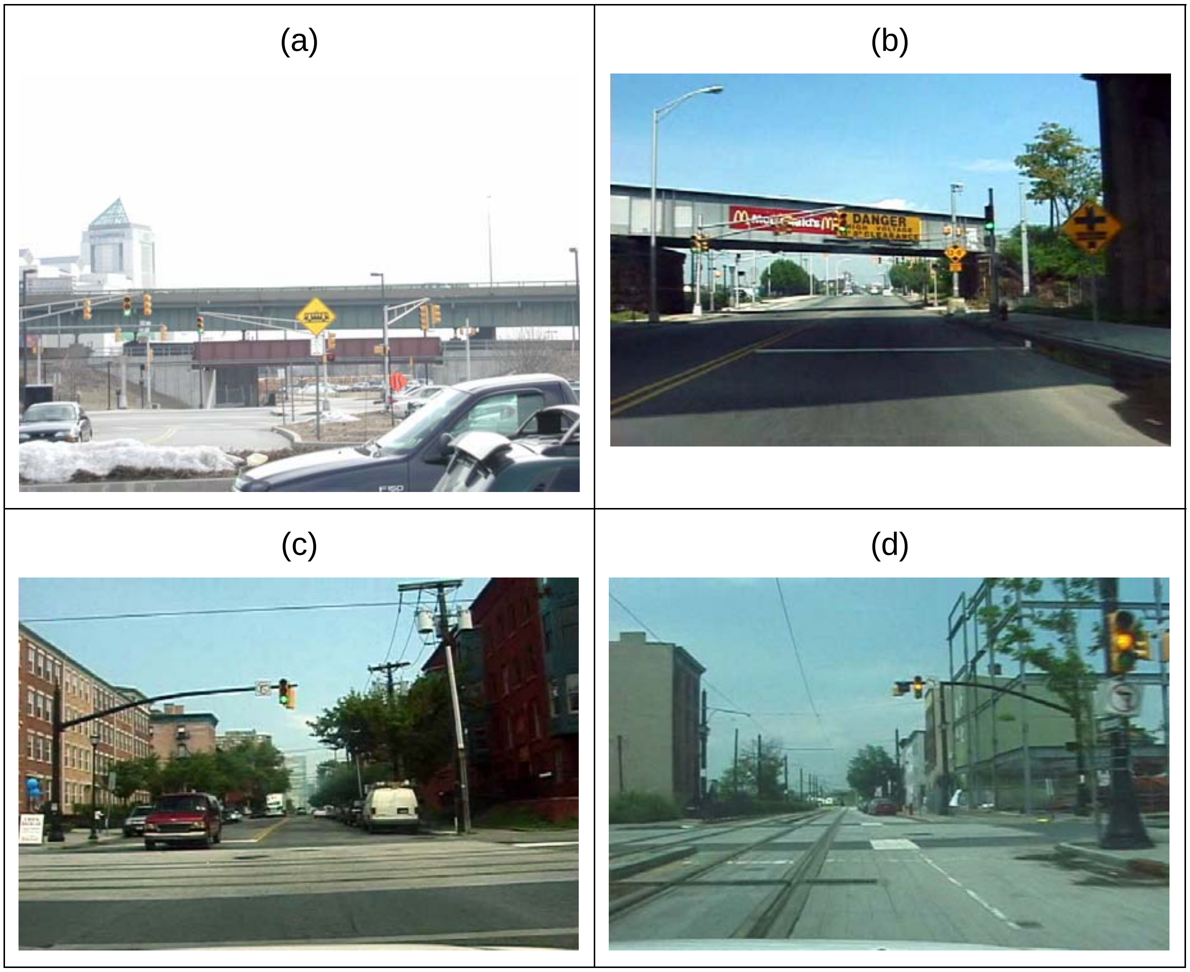


Figure 3. Traffic control devices and roadway layout at light rail crossings: (a) light rail warning sign and traffic signal lights, (b) warning sign showing roadway parallel rail tracks, (c) light rail tracks at crossing, (d) two-way, single-lane road shared by light rail trains and automobiles.

Apparatus

The equipment utilized for the experiment was a PC (Pentium III 1000 MHz) along with a standard keyboard, mouse and loudspeakers. The images were displayed on a screen using a computer projector (Epson Powerlite 7250). The projected image on a screen was 72 inches diagonal in size. Subjects were positioned 9 feet from the screen. An experimenter monitored the progress of the experiment and subject responses with a separate computer display using a dual monitor function of the computer. A total of 22 video clips were randomly presented to subjects. Video editing software Adobe Premiere® was used to process raw videos into MPEG-4 files. The length of each final video clip ranged between 12 and 15 seconds. A Visual Basic computer program was developed by the NJIT research team to bring an interactive user interface to subjects.

Subjects

Forty subjects who possessed valid New Jersey driver licenses participated in the experiment. Among the 40 subjects, 21 were male and 19 were female. The age of the subjects ranges between 18 and 73 years old. Subjects were recruited from on and off NJIT campus announcement posted on public bulletin boards.

Procedures

Subjects were briefed about the procedure of the experiment by an experimenter upon reporting to the human factors laboratory at NJIT (see Appendix B for experiment instructions). Each subject was given practice trials prior to the formal experiment. Responses from the practice trials were not used in the data analyses. Subjects were instructed that they can play each video clip one more time if they chose to. They were prompted with one to two questions regarding their judgment after having viewed each video clip. The questions are selected from a pool of nine questions (see Appendix C). Same questions are asked for the same video clip for all subjects. Subjects self-controlled the pace of answering questions and proceeded to the next video clip. The sequence of the 22 video clips was randomly presented to each subject and counter-balanced between subjects. During the experiment, subjects were allowed to take brief breaks after each trial. Figure 4 shows that a subject was undergoing the laboratory experiment.

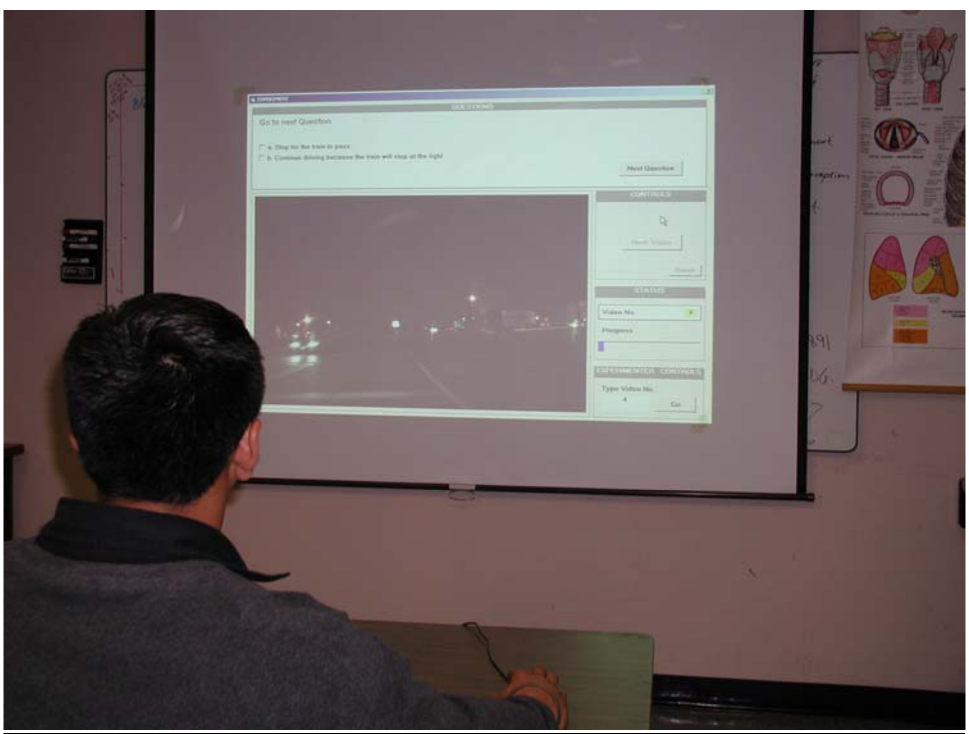


Figure 4 Subject in the driver perception laboratory experiment.

Statistical Analysis

Results of the human factor laboratory experiments were analyzed using several statistical approaches to better understand the relationships between subjects' perception, decision making, and display conditions of various warning devices at various types of railroad/light rail crossings. Analysis of variance, t-test and Chi-square were used for performance affected by independent variables.

RESULTS AND DISCUSSION

Results and discussion of the study are introduced in the order of (1) Experiment I: Driving perception and behavior, (2) Experiment II: Driver test on draft railroad section for driver manuals, and (3) Development of draft railroad crossing section for New Jersey driver manuals.

Experiment I: Driving Perception and Behavior

The research team visited railroad grade crossings in Hackensack, Jersey City, Morristown, and North Brunswick in New Jersey between 2001 and 2003. Video recordings were taken place in-vehicle at grade crossings of various configurations, including grade crossings with regular and special active/passive TCD, crossings of light rail trains, day time and night time, as well as interactions without any grade crossings serving as catch trials. There were 24 video clips used in the experiment, including two video clips for practice, four video clips showing night time driving conditions, and two video clips containing no grade crossing to serve as catch trials to subjects.

A total of 40 subjects participated in the first experiment for studying driver perception and decision making behaviors upon viewing a vehicle approaches railroad grade crossings. Results from two subjects, however, were discarded based on their faulty responses in catch trials. The valid data were from 21 males and 17 females. The age range of subjects was between 73 years old and 18 years old (mean = 37.9 years old, *s.d.*= 14.6). The subjects had driving experience between one year and 44 years (mean = 16.1 years, *s.d.* = 13.6 years). 44% of the subjects indicated that they had involved in at least one car accident and 56% did not have any car accident in their driving record. Among the subjects, 29 subjects had non-commercial driver license, 4 subjects had Class B commercial driver license, and 5 subjects had Class C commercial driver license.

In the experiment subjects were asked to choose movements of a vehicle in responding to different settings of traffic control devices appeared around railroad grade crossings while a vehicle was approaching the crossings. The choices included “slow down”, “speed up”, keep same speed”, and “stop”. Table 1 shows percent of responses that subjects selected to different settings of traffic control devices at railroad grade crossings. More subjects indicated that they would keep the same speed (54.2% and 58.3%) than slow down (29.2% and 39.5%) during the time when the signals were in their offset phase where active traffic control devices were in place ($p<.05$). More subjects would choose to slow down (70.8% and 79.2%) than to keep the same speed (25.0 and 8.3%) at railroad crossings with passive traffic control devices ($p<.05$). The opposite trend in responses to active versus passive traffic control devices at railroad crossings showed that overall subjects were aware the differences of traffic control devices at different railroad crossings shown in the video clips. There was no difference between day time and night time on vehicle speed control upon approaching grade crossings when flashing lights were in their offset signal phase (p >.05). The above responses, however, only indicated subjects' perception and awareness of observing those traffic control devices rather than predicting their actual driving behavior.

Table 1. Driver perception: Percent response when approaching railroad crossings.

Traffic Control Device Settings at Railroad Grade Crossings	Subject Speed Control Selection			
	Slow Down	Speed Up	Same Speed	Stop
Active: gate, flashing light	29.2%	0.0%	58.3%	12.5%
Active: flashing light	39.5%	0.0%	54.2%	4.2%
Active: flashing light, night time condition	39.5%	0.0%	52.6%	8.3%
Passive crossing 1	70.8%	0.0%	25.0%	4.2%
Passive crossing 2	79.2%	0.0%	8.3%	12.5%

In addition to asking subjects about their perception and vehicle speed control decision under the above conditions, the experiment also tested subjects about special signs/layout at railroad and light rail crossings. When the stop sign appeared at a location where a grade crossing and an intersection of roads for automobiles were close to each other, 8.3% of subjects perceived that the stop sign was for the railroad crossing, 37.5% of subjects thought it was for the intersection of roads for automobiles, and 57.2% regard it was for both the railroad crossing and the intersection of roads for automobiles. The experiment tested hypothetical situations which were not shown in the video clips. When asked what would happen to the signal lights at a grade crossing if a train was approaching, 65.8% of subjects felt that the light would turn "steady red", while 34.2% of subjects thought that there would be a flashing read light.

When subjects were asked what they should respond "if a light rail train was 100 ft away from the crossing while the car was about to reach the crossing," 79.2% of subjects would stop for the light rail train because they thought the signal lights would turn red because the train always had the highest priority. 20.8% of subjects would continue driving because the train would follow the traffic signals. When the signal lights were at crossings for light rail trains, 54.2% of subjects anticipated that the light would turn "steady red", while 41.7% of subjects thought that there would be a flashing red light. When the video showed that a vehicle was left turning to a lane of a road which was shared by light rail trains and automobiles (see Figure 3(d)), 79.2% of subjects perceived that the car needed to “shift lane” and 20.8% chose to stay on the shared lane. While the video showed the car was traveling on the train/automobile shared lane, subjects were asked what they should do if they saw a light rail train approaching from behind. 60.7% of subjects perceived that the car needed to “shift lane”, 33.1% chose to stay on the shared lane, and 4.2% thought that the car might be driving on a wrong direction of the road.

Discussion of the Driver Perception Experiment Results

Results of the driver perception laboratory experiment had several implications. First, subjects responded differently to railroad crossings equipped with active and passive traffic control devices. Most subjects were aware of the function of active traffic control devices at railroad crossings. When those active devices, namely gates and flashing red lights, were in their offset phase, subjects would choose to keep the same driving speed more than for railroad crossings with passive traffic control devices. The response difference would support new “NO GATE OR LIGHTS” or “NO SIGNAL” signs being proposed for new Manual on Uniform Traffic Control Devices (MUTCD). Stop signs at railroad crossing areas should be used carefully since many drivers might regard the sign is applied exclusively at roadway intersections of automobiles. The red light of traffic signal lights existing in some railroad crossing areas functions the same as the flashing red lights used commonly at railroad grade crossings. Driver manuals should clearly instruct drivers proper responses to the steady red light and the flashing red light both exist at different railroad grade crossings.

Most subjects had difficulties making correct judgments about special crossing conditions and road configurations where light rail trains exist. Many of them thought that the light rail train always has the highest priority therefore automobiles should yield to the train at all time. Consequently it might affect driver’s decision making in situations such as driving on the train-automobile shared lane and hesitating to drive through crossings when it is green light to vehicles. Confusion and hesitation may pose a higher risk of traffic accidents to those drivers who are unfamiliar with special conditions at light rail crossings. It is necessary to separately introduce the specifics and safety tips to light rail trains and light rail crossings in driver manuals.

Based on literature review and results of the driver perception laboratory experiment, a proposed railroad section for the New Jersey driver manuals was drafted by the NJIT research team through the contracted work of Dr. Srinivasan. In order to evaluate the effectiveness of the draft railroad section, the NJIT research team created a 30 question written test for drivers (see Appendix D). The next section covers the results of the written test.

Experiment II: Driver Test on Draft Railroad Section for Driver Manuals

The 30 question written consisted of two parts, namely general traffic safety and safety at railroad grade crossings. There were 10 questions for the general traffic safety part and 20 questions for the railroad grade crossings part. Additional forty subjects participated in the written test. The forty subjects were grouped into (1) no driver license/current driver manual, (2) driver license/current driver manual groups, (3) no driver license/additional draft railroad section, (4) driver license/additional draft railroad section. Each group consisted of ten subjects. The demographics of subjects are in Table 2.

Table 2. Demographics of forty subjects participated in the written test.

Subject Demographics	Materials Available to Subjects during Experiment			
	Current Driver Manual		Additional Railroad Section	
NJ Driver License	No	Yes	No	Yes
Male	5	5	5	5
Female	5	5	5	5
Age (*standard deviation.*)	20.0 (*2.7*)	39.9 (*17.1*)	20.2 (*2.3*)	35.5 (*14.2*)
Edu: High School	3	4	5	4
Edu: College	5	5	4	4
Edu: Advanced Degree	1	1	1	2
Driving Experience (*S.D.*)	0.7† (*1.5*)	18.5 (*14.8*)	0.0 (*0.0*)	12.8 (*13.1*)

† Note: two subjects reported that they obtained driver licenses from foreign countries.

The overall findings from the written test experiment show that those subjects who have New Jersey driver licenses made less mistakes, on both general traffic safety questions and questions pertaining to railroad crossings, than those who do not have New Jersey driver licenses. The difference is statistically significant ($p < .01$) (see Table 3). No performance difference on general traffic safety questions was found between subjects in the experimental groups (with and without NJ driver licenses) and subjects in the control groups (with and without NJ driver licenses) ($p > .05$). Subjects in the experimental groups (having extra railroad crossing section material) performed significantly better than subjects in the control groups (having regular NJ driver manual only) ($p<.05$). Subjects in the experimental groups made approximately 1.8 mistakes (out of 20 questions) less than their counterparts in the control groups (see Table 3).

Table 3. Average number of errors made by subjects in four treatment groups.

	Numbers of Errors (*Standard Deviation*)			
	Materials Available to Subjects during Experiment			
	Current Driver Manual		Additional Railroad Section	
NJ Driver License	No	Yes	No	Yes
Part I- General traffic safety	2.1 *(0.57)*	1.4 *(0.70)*	2.4 *(1.35)*	1.5 *(0.85)*
Part II- Railroad crossings	5.9 *(1.79)*	4.4 *(2.37)*	4.0 *(1.70)*	2.8 *(1.40)*

Discussion of the Driver Test Experiment Results

Results of the written test experiment showed that subjects with NJ driver licenses performed better than subjects without NJ driver licenses. The better performance for subjects with NJ driver licenses than without NJ driver licenses can be explained because those subjects who have NJ driver licenses had already passed the state required written test. It may also suggest that driving experience in New Jersey may have helped on their written test performance. Since subjects were randomly assigned into either experimental or control groups, the fact that no performance difference was found between experimental groups and control groups on ten general traffic safety questions confirmed the random assignment of subject groups.

Subjects in the experimental groups performed significantly better than subjects in the control group on 20 questions which address railroad crossing issues. It suggests that the draft railroad crossing section for NJ driver manual helps readers to better understand issues related to driving safety on railroad crossings than the current NJ driver manual. Subjects can learn the subject in a holistic view of all safety concerns related to driving across railroad crossings in the same section if the driver manual is in such a format. The full benefit of having a railroad crossing section in a driver manual may be even more than what the results had shown in the written test experiment since the experiment only gave one hour total time to subjects to review the driver manual and the draft railroad crossing section.

Development of driver manual section on railroad grade crossings

A draft railroad crossing section for New Jersey driver manuals was developed based on literature review and results of the first experiment of this study. The draft section is included in Appendix E. Below is a discussion of the development.

The three main approaches to reducing road accidents are commonly referred to as the three E's: engineering, education, and enforcement. In order for all road users to be aware of the safe and proper way to use the road system, it is necessary that they are educated about the rules, regulations, and expectations in the using the roadway system. An important step in achieving this is to ensure that the driver's manual is accurate and easy to read and comprehend. One of the important objectives of this study is to develop a section of the driver manual on railroad grade crossings that is user-friendly and communicates to the user how to negotiate railroad grade crossings in a safe manner.

<u>Resources for developing the section</u>

The following resources were used in the development of the railroad grade crossing section of the driver's manual:

- Driver manuals from other States
- Lerner, N.D., Llaneras, R.E., McGee, H.W., and Stephens, D.E., NCHRP Report 470: *Traffic-Control Devices for Passive Railroad-Highway Grade Crossings*, TRB, 2002.
- 2003 Edition of the Manual on Uniform Traffic Control Devices for Streets and Highways: Part 8 – Traffic Control Devices for Highway-Rail Grade Crossings; Part 10 – Traffic Controls for Highway-Light Rail Transit Grade Crossings.

Based on an analysis of these documents, it is clear that the new manual should integrate pictures, photographs, and text, to provide scenarios that readers can understand clearly.

<u>Review of driver manuals from other States</u>

The first step involved a brief review of the driver manuals from all 50 States in order to assess the extent to which railroad crossings were discussed. Following this, 22 States were selected for more in-depth review of their manuals. The primary criteria for selecting these States was the extent to which railroad crossings were covered, and whether the manual integrated pictures and text to facilitate comprehension. Table 4 summarizes the key features of each State's discussion of railroad crossings in their driver manuals.

Table 4. Key features of each state's discussion of railroad crossing in their driver manuals.

State	Discussion of the railroad grade crossing issue
New York	• Table of contents of the driver manual does not mention railroad crossings • There is no mention about pavement markings that drivers will encounter as they approach railroad crossings • More discussion about passive crossings and crossings with flashing lights and no gates, is necessary
Ohio	• Table of contents indicate that railroad crossings are included as a section in Chapter 6 (traffic laws) • Although pavement markings, the crossbuck sign, flashing red lights, and stop signs are discussed verbally, the manual does not seem to show a picture of these devices
Illinois	• Table of contents of the driver manual does not mention railroad crossings • Overall, a *good* discussion about railroad crossings • Manual does not show a picture of the pavement markings • Railroad crossings are discussed in two different places. An integrated discussion of the topic in one place would be better.
California	• Table of contents lists railroad crossings as a subsection under section entitled 'Sharing the road with other vehicles'. • No pictures of the crossbuck sign, pavement markings, gates, and flashing lights. • Discussion of passive crossings is too brief.
Arkansas	• In the table of contents, railroad crossings are included as a subsection under a section entitled 'safe driving tips'. • The manual mentions that "at some crossings, along with the crossbuck sign, you will see side-by-side lights that flash alternatively". However, there is no discussion on what drivers are supposed to do when they see this. • Manual does not show a picture of the pavement markings
Alabama	• The electronic copy of the manual does not show a table of contents. • Overall, a *good* discussion about railroad crossings. • More detail about passive crossings will be useful.
Utah	• Table of contents show 'railroad crossing' as a section in Chapter 5: basic driving skills. • One of the figures incorrectly shows the advance warning sign instead of the crossbuck sign at the crossing.

	• There is a detailed discussion about the appropriate response to different types of crossings using pictures. • The discussion about light rail is unique. • Overall, a *very good* discussion about railroad crossings.
Oklahoma	• The table of contents indicates that "Railroad crossings" and "trains" are mentioned in two places in the driver's manual. Once in Chapter 5 (Signs, signals, and markings), and in Chapter 11 (Sharing the road). • Page 5-7 shows the advance warning sign, crossbuck, flashing lights, and gates, and the appropriate response to different types of crossings that may have these devices. • Pages 11-6 through 11-10 have a detailed discussion with pictures about the appropriate response in different situations. • The manual is very clear about what drivers should do when they encounter a crossing with lights but no gates: "Drivers always stop when the lights are flashing, and *cross only when the lights stop flashing* (page 11-7)." In some other States, although the intent may be the same, the wording is a little ambiguous. • Overall, an *excellent* discussion about railroad crossings.
Oregon	• In the table of contents, "Railroad crossing signs" and "Railroad crossings" are mentioned as subsections (in pages 19 and 25) within Section 2 on Highway signs, signals, and markings. • Overall, a *good* discussion about crossings using pictures. • More detailed discussion about appropriate behavior would be useful, especially at passive crossings with no lights or gates.
Colorado	• In the table of contents, "Railroad crossings" and "Light rail" are shown as subsections (in page 23) within Section 12 on Sharing the road. • Page 13 shows the crossbuck sign and the advance warning sign, but does not say which is which! • Pages 23 and 24 have a detailed discussion about light rail crossings, vehicles, and expected response from motorists. This is a unique feature of this State. • There should be more discussion about passive crossings and the expected behavior at these crossings.
Texas	• Railroad crossings are not mentioned in the table of contents. • Railroad crossings are first discussed in Chapter 4 (right of way). In page 4-5, the manual introduces the word crossbuck, apparently for the first time, but with no picture. In pages 4-4 and 4-5, the manual describes the appropriate behavior at three types of crossings: (1) only a crossbuck

	sign, (2) crossbuck with flashing lights, and (3) crossbuck with flashing lights and gates. • Page 5-18 in Chapter 5 (Signals, signs, and markers) discuss railroad warning signs. A picture of the round advance warning sign, the crossbuck, and a crossbuck with lights and gates are shown. • Overall, a *good* discussion about railroad crossings, although pavement markings near railroad crossings are not mentioned. • The presentation will be more effective if the material in pages 4-4, 4-5, and 5-18 are integrated in one place.
Louisiana	• Table of contents do not include specifically mention railroad crossings. • Overall, a *good* discussion about railroad crossings. • It is important to note that the manual warns drivers "to look both ways as you approach a crossing, even if warning lights are not flashing, because they may not be working".
Minnesota	• No specific mention about railroad crossings in the table of contents. • Separate section on railroad crossings in "Chapter 3: Minnesota traffic laws: sharing the road". Pages 40 and 41 in this section provide general guidance to the driver about using additional caution at railroad grade crossings. • Page 45 shows traffic control devices at crossings. Pavement markings are discussed, but their picture is not shown. • There should be a more detailed discussion about the appropriate driver behavior at different types of crossings, especially passive crossings. It will be more effective if the discussion in pages 40-41 and 45 are integrated in one place.
Missouri	• Railroad crossings are included as a sub-section starting in page 10 of Chapter 3 on Pavement Markings, Traffic Signs, Lights, and Signals. • A concise description of railroad crossings is presented with some discussion about the difference between crossings with and without flashing lights and / or gates. Pavement markings are discussed, but not shown in a picture. • Only one picture with a perspective view of a railroad crossing is shown. Several pictures with different views will make a more effective presentation.
North Carolina	• Railroad crossings are not mentioned in the table of contents. • Railroad crossings are initially discussed on page 53 in Chapter 4 (your driving). Detailed instructions are provided about expected behavior when flashing lights and / or gates are used.

	• Traffic control devices at railroad crossings are illustrated on page 83 in Chapter 5 (Signals and Signs). • Overall, a *good* discussion about railroad crossings. A picture of the pavement markings will be useful. It will be useful to combine the discussion in pages 53 and 83 in one place. More discussion about dealing with passive crossings will be useful.
Wisconsin	• Railroad crossings are not mentioned in the table of contents. • Railroad crossings are discussed in pages 13 and 14 in subsection Traffic Signs. All the traffic control devices are discussed. Appropriate behavior in different types of situations is discussed. • Overall, a *good* discussion about railroad crossings. A picture of the pavement markings would be a useful addition.
Indiana	• Railroad crossings are not mentioned in the table of contents. • Page 24 in Article III (Chapter A: basic traffic signs) shows a picture of the advance railroad warning sign that drivers will encounter as they approach a crossing. • Page 41 in Article III (Chapter D: Safety vehicle operation in specific situations) has a 1 page description of general guidelines about dealing with railroad grade crossings. • There are no pictures of the crossbuck, flashing lights, and gates, although they are briefly mentioned on page 41. • There is no discussion about the appropriate response at a crossing with only flashing lights and no gates.
Pennsylvania	• Railroad crossings are not specifically mentioned in the table of contents. • The crossbuck, flashing lights, and gates are discussed on page 9, which is in Chapter 2 (Signals, signs, and pavement markings). Here, most of the discussion is about crossings with flashing lights and / or gates. • The advance warning sign is shown in page 16, which is also part of Chapter 2. • Railroad crossings are also discussed in page 49, which is in Chapter 3 (Learning to Drive). Here, the manual mentions that most crossings do not have gates or lights and extra caution is required. • Overall, a *good* discussion about railroad crossings, although a more integrated discussion in one place (rather than in two places) will be more effective. A picture of pavement markings should be added.
Kansas	• The table of contents list railroad crossings as a sub-section on page 48 (within the section on Sign, Signals, and Markings). • The railroad advance warning sign is described on page 34.

	Manual mentions that the circular sign is used only for advance warnings to railroad crossings. • Pages 48 and 49 provide a detailed discussion of crossings. Different types of crossings and the appropriate response is discussed. • Overall, a *good* discussion about railroad crossings. Picture of the pavement markings will be useful.
Florida	• Only an html copy of the driver manual was available in electronic form. The table of contents does not specifically mention railroad crossings. • Pages 4, 11, and 12, of Chapter 4 discuss railroad crossings. A picture of the crossbuck is shown in both places. Page 4 also mentions that a round shaped sign indicates a railroad advance warning sign. • Pages 11 and 12 discuss the proper response that drivers should take when they encounter these crossings. • The pictures are too small and not very clear, although the discussion addresses most of the important issues. No picture of pavement markings.
Nebraska	• The table of contents mention that railroad crossings are discussed in section 4F (page 44). • Section 3A (page 22) has a discussion about traffic signals and the associated conventions. In the case of the flashing red light, it is clearly mentioned that, "a flashing red light at a railroad crossing requires a complete stop even if a train is not visible". • Page 25 (Section 3B-2 on 'Sign Shapes') just shows a picture of the advance warning sign, and the crossbuck with flashing lights. • Section 4F (page 44) is a discussion of how to respond when approaching different types of railroad crossing. In addition to the active traffic control devices, drivers are asked to stop if "train is clearly visible or train whistle if heard and it would hazardous to cross". • <u>Comments.</u> It will be useful if the discussion and the picture are integrated in one place, instead of in two different sections. A picture of the pavement markings will be useful.
New Jersey	• Table of contents do not specifically mention railroad crossings. • Railroad crossings are initially discussed in page 44 under the heading 'stop at railroad crossings'. This is a subsection under the section 'turning regulations'. In this section, the manual gives an overview of different types of railroad crossings, and the expected response under different conditions.

	• A picture of the advance warning sign is shown on page 108 under the section entitled 'Traffic signs, signals, and road markings'. • The pavement markings encountered by drivers at railroad crossings are discussed in page 112 with a picture. There is also a brief discussion of different types of crossings. • The manual does not seem to show a picture of the crossbuck. In addition, it will be useful to integrate the discussion in pages 44, 108, and 112, in one area, add more pictures, and discuss the issues in more detail.

<u>Review of MUTCD and NCHRP Report 470</u>

Parts 8 and 10 of MUTCD and NCHRP Report 470 were reviewed to ensure that the latest information on traffic control devices at railroad crossings and light rail crossings were included. NCHRP Report 470 recommended a supplemental sign at passive crossings ("NO GATES OR LIGHTS") that was implemented in the 2003 edition of MUTCD.

<u>Section of driver manual on railroad crossings</u>

Following a review of the MUTCD, NCHRP Report 470, and the driver manuals from the 22 States, a DRAFT section of the driver manual on railroad crossings was developed for New Jersey. The first part of the section talks about 'Sharing the road with trains,' and the second part discusses 'Sharing the road with light rail vehicles'.

Sharing the road with trains

In this section, there is a detailed discussion on every traffic control device that a driver can expect to encounter as they approach railroad grade crossings in New Jersey. All traffic control devices are described using pictures. There is also a discussion of what each motorist is expected to do as they encounter these traffic control devices.

Following this is a series of 'Safety tips' for motorists that encounter railroad crossings. Wherever necessary, the safety tips are supplemented by pictures to convey the message further.

Sharing the road with light rail vehicles

This subsection includes a description of traffic control devices (including pictures) that motorists would see as they encounter light rail vehicles and light rail crossings. There is also a discussion of pedestrian and driver safety tips along with necessary pictures and figures.

CONCLUSION AND RECOMMENDATIONS

This project utilized human factors research approaches to study driver perceptions and driving decision makings to all driving safety issues pertaining to railroad grade crossings. First, the research team conducted a laboratory experiment to study driver perception and driving decision making using video clips taken from a moving vehicles traveling through various railroad grade crossings. Second, a draft railroad section for driver manuals was developed. A second experiment was conducted to study the effectiveness of the draft railroad section to the understanding of railroad crossing related safety issues to readers. The following highlights the main findings and recommendations derived from this project:

- Drivers in general have different driving behaviors on approaching typical active crossings (gates and/or red flashing lights) and passive crossings.

- Unusual traffic control devices used in the vicinity of railroad grade crossings, such as stop sign and traffic signal lights, should be implemented carefully to avoid confusion to drivers.

- Many drivers are not familiar with traffic control devices or roadway layout at light rail crossings. Specific and comprehensive instructions pertaining to driving at light rail crossings should be provided in the driver manuals.

- The draft railroad section for New Jersey driver manuals has been tested on its efficacy of instructing drivers about safe driving at grade crossings equipped with various traffic control devices, including light rail crossings. The results show positive performance gained from having such a dedicate railroad section in the driver manual. It is therefore recommended that the draft railroad section be adopted into future development of all New Jersey driver manuals.

- Human factors research methodology proved to be an effective approach of studying driver perception and driving behaviors for the current traffic safety project. There are many issues related to traffic safety in New Jersey which involves driver perception and decision makings in driving should be investigated using human factors approaches.

APPENDIX A

Literature Review:

Summaries of Individual Studies by Topic Area

STUDY OF DRIVER BEHAVIOR AND DRIVER CHARACTERISTICS

1. J.H. Sanders (1976), “Driver Performance In Countermeasure Development at Railroad – Highway Grade Crossings”, *Transportation Research Record* 562, pp. 28-37.

Objectives

- To understand the driver population and the behavior drivers display at grade crossings
- To identify driver characteristics that be used to predict driver performance

Methodology and Data Collection

Nine railroad-highway grade crossings were included: 3 passive crossings, and 6 active crossings. Crossings were located in Virginia, Texas, Michigan, and California. All crossings were instrumented with an automated system for collection of time and position data on vehicles. The system tracked all vehicles for 500 feet as they approached the crossings, and provided data on speed, acceleration, and relationships between adjacent vehicles. In addition, data on driver looking behavior, activations of crossing signals, train arrival times, and train speeds, were obtained. 1,267 drivers also completed questionnaires.

Results and Conclusion

- Drivers slow down for crossings because most crossings are bumpy
- Drivers generally underestimated their speed by about 30 percent, indicating the hazard if a driver has to stop for an unexpected train
- The question “Do all railroad crossings have a signal or gate that warns you when a train is coming?” produced surprising answers. When asked at active crossings, 22.8% of the drivers said ‘Yes.’ When asked of drivers at passive crossings, 15.4% said ‘Yes.’ At the crossing studied in California, more than 35% stated that all crossings had active warning systems.
- Thirty five percent of drivers could recall no safety instruction or advice on crossing safety.
- Drivers who were observed to perform more safely more frequently correctly identified or remembered the characteristics of protective devices at the crossing.
- Percentage of reduction in the speed was lower for drivers with high familiarity than for very unfamiliar drivers.
- Drivers who performed less safely according to the behavior measures tended to score more highly as risk takers.
- Drivers who reported long delays when stopped at grade crossings tended to behave less safely.

Some Thoughts

Some of the results are consistent with observations and results from more recent studies. However, one could argue that driver education with railroad crossings has improved in recent years at least in some states. Hence, a similar study conducted today may give results that may be at least slightly different.

2. S.H. Richards and K.W. Heathington (1988), “Motorist understanding of railroad-highway grade crossing traffic control devices and associated traffic laws”, *Transportation Research Record* 1160, pp. 52-59.

Objectives

Study motorist understanding of railroad-highway grade crossing traffic control devices and associated traffic flows.

Methodology

Data for the research were gathered by using a questionnaire with 16 multiple-choice and 1 short-answer questions. The survey was conducted in three Tennessee cities: Nashville, Chattanooga, and Knoxville. The majority of the questionnaires were administered to visitors at driver licensing center. A limited number of surveys were also given to a limited number of staff members at the University of Tennessee in Knoxville.

A total of 176 motorists were sampled from the general driver population. A second, smaller survey of 35 Tennessee police officers was also conducted.

Results

- Only about one third of the survey participants (34.8%) said that they received instruction, training, or both on crossing safety during a driver education course.
- 76.3% of the survey participants correctly identified the crossbuck sign as the one placed at the crossing. However, 19.0% of the drivers incorrectly identified the railroad advance warning sign as the one placed at the crossing.
- When subjects were asked about the appropriate response to a crossbuck sign at a passive crossing, 24.3% of the subjects gave the correct response, i.e., be ready to stop if you see or hear a train. Most subjects (69.6%) said that at passive crossings, one should stop, look, and listen for a train.

- 21.7% of all participants (and 62.5% of drivers 18 years and below) believed that flashing light signals appear at all crossings.
- 5.2% of the survey participants said that traffic should drive around lowered gates if no train is coming.
- Over 18% of the survey sample did not know that the stopping distance of the train was much greater than that of a truck or car.

Conclusion

Results indicate that a significant proportion of the population is not knowledgeable about the appropriate response to different types of traffic controls at grade crossings. This emphasizes the importance of educating the public through different media.

3. S.H. Richards and K.W. Heathington (1990), "Assessment of warning time needs at railroad-highway grade crossings with active traffic control", *Transportation Research Record* 1254, pp. 72-84.

Objectives

Assess the effects of warning time on driver behavior and safety at railroad-highway grade crossings with active traffic control.

Methodology and Data Collection

Field Study

Data for the warning time evaluations were taken from videotapes of driver behavior at three crossings in the Knoxville, Tennessee area. Two of the crossings had standard flashing light signals, whereas the third crossing had standard gates with flashing light signals. Data were collected on violations and clearance times between a crossing vehicle and the arrival of a train. The actions of over 3500 motorists were evaluated during 445 train events.

Human Factors Laboratory Study

Sixty driver subjects were shown videotapes of staged traffic control device activation events at active grade crossings. While individual viewing an activation event, each subject was asked to indicate: (1) when he or she would expect a train to arrive at the crossing, and (2) when the elapsed time without a train arriving had become too long.

Results

Field Study

Generally, a very high percentage of drivers waited at crossings if the waiting time was relatively short, i.e., 20-30 seconds. However, as the warning times increased beyond 30 seconds, the percentage of drivers who stopped and waited declined steadily.

Human Factors Laboratory Study

Most drivers expect a train to arrive within 20 seconds from the moment when the traffic control devices are activated. Drivers begin to lose confidence in the traffic control system if the warning time exceeds 40 seconds at crossings with flashing light signals and 60 seconds at gated crossing.

4. J. Abraham, T.K. Datta, and S. Datta (1998), “Driver behavior at rail-highway crossings”, *Transportation Research Record* 1648, pp. 28-34.

Objective

To study driver behavior and accidents at active rail-highways with gates in Michigan

Methodology and Data Collection

A total of 37 rail-highway crossing sites with flashing lights and gates, in the southeastern and western parts of the Michigan, were selected for the study. A video camera was used. License plates were recorded manually. Field observers were stationed on both sides of a crossing on the roadside, equipped with a tape recorder and a writing pad and pen. As a violated vehicle passed, a brief description of the vehicle and the driver was recorded along with the license plate number. Data collection was performed for a total of 126 days for an average of 2.5h each day.

Questionnaires were mailed to 820 vehicle owners (violators). Violations were also classified as routine, risky, more risky, severe, and critical, depending on whether the violation happened after the train had passed, before the train had passed the crossing, and the duration between the vehicle crossing the tracks and the arrival of the train at the crossing.

Crash data from the last 7 years were also analyzed.

Results

276 surveys were returned. More than 85% of respondents mentioned that they cross the specific rail-crossing at least 2 times a week, indicating that they were probably familiar with the crossing. Respondents also stated that they violated the traffic law because the ‘train was not in sight’ or the train was ‘stopped for an unreasonable amount of time.’

Severe and critical violations constituted 21% of the total number of violations. Male drivers constituted 64% of the violations. This may indicate that male drivers take more risks, however, the difference may also be due to the higher percentage of male drivers in the population.

Based on the analysis of the crash data, the authors concluded that motorists approaching a multi-track crossing from a multilane approach commit more violations and that such sites have experienced more crashes possibly because in sites with multiple lanes, motorists find enough room to driver around gates, giving them a false sense of security.

Some observations

Based on the field data collection, the following observations were made about motorist behavior:

- A number of situations were observed when the gates were rising and impatient motorists tried to go around the gates, often creating confusion and potential vehicle-to-vehicle conflicts.
- Sometimes drivers forget that another train may be crossing from a different direction. This can happen especially at crossings with more than one track.

- Sometimes motorists speeded to clear the crossing when they saw the flashing red signal or the gates coming down. This may cause vehicle-to-vehicle collisions, particularly at locations where there are signalized intersections in the downstream proximity.

- One driver driving around the gates sometimes leads to other drivers following this first vehicle.

5. P.J. Carlson and K. Fitzpatrick (1999), "Violations at gated highway-railroad grade crossings", *Transportation Research Record* 1692, pp. 66-73.

Objectives

To identify operational and geometric variables that may influence violations at gated highway-railroad grade crossings.

Methodology and Data Collection

Data were recorded using mobile video recording systems in 19 railroad-crossing sites. Data were collected during weekdays for a minimum of 23 hours at each site. Each video had a time stamp superimposed and used to collect data on: signal onset, gate activation, gates in completely lowered position, violation (if any occurred), train arrival, train at each speed marker point, train departure, time gates began to rise, and time gates were completely raised. Similar to the study conducted by Abraham, Datta, and Datta (1998), violations were classified into three groups, based on time gap between vehicle crossing the tracks and the arrival of the train, and whether the violation occurred after the train left the crossing.

Logistic regression models were developed to study the probability of committing a violation as a function of variables such as warning time, sight distance, train speed, number of tracks, and number lanes.

Results

The logistic regression models indicated that an increase in train speed, longer warning times, and an increase in the number of lanes, can lead to an increase in the probability of a violation. These results are quite consistent with results from other studies already reported.

Some crossings experienced occasional false activations, i.e., light is flashing and gate comes down, but there is no train. This may promote motorist disrespect.

6. R. Hughes, R. Stewart, and E. Rodgman (1999), "Prior driver performance and expressed attitudes toward risk factors associated with railroad grade crossing violations", Highway Safety Research Center (HSRC), University of North Carolina, June.

Objectives:

To study the relationship between prior driver performance, attitudes toward risk factors, and violations at railroad grade crossings.

Methodology and Data Collection:

Railroad gate runners identified by photo surveillance instrumentation were contrasted with a sample of general users of the same grade crossing. The two samples were contrasted in terms of the prior driving histories of the drivers involved. In addition, drivers in the sample of general users were administered a paper and pencil questionnaire developed by HSRC addressing drivers' perception of the risks associated with grade crossing actions and similar actions at signalized intersections.

Results:

Violators were over-represented in the age ranges of 16-30 and 31-60. With respect to the gender of violators, the male/female ratio in the violator group did not differ from that of the general user population. Data suggested that a driver's prior history of violations and crash involvement combined with his or her generalized orientation to the assessment and acceptance of risk may be related to and increased likelihood of 'gate running'.

7. K. Witte and W.A. Donohue (2000), "Preventing vehicle crashes with trains at grade crossings: the risk seeker challenge", *Accident Analysis and Prevention*, Vol. 32, pp. 127-139.

Objectives:

This study was undertaken to first identify the kinds of individuals most vulnerable to train crashes in the state of Michigan, and second to conduct a theoretically-based formative evaluation to discover relevant perceptions, beliefs, and behaviors to target in a public communication campaign. In addition, researchers were interested in answers to the following questions:
(1) What proportion of the population is engaging in risky railway behaviors?
(2) What are the characteristics of risky vs. not- risky drivers?
(3) What is the relationship between sensation seeking tendencies and the variables in the reviewed theories (i.e. severity, self-efficacy, response efficacy, errors in judgment, prior experiences)?

Methodology and Data Collection:

A survey was designed to measure the following variables dealing with Michigan's motoring public: (a) perceived severity of the threat of train injury at grade crossings; (b) perceived susceptibility and emotional responses to train crashes; (c) perceived efficacy of being able to perform the recommended response; (d) perceived ability to perform the recommended response; (e) errors in judgment; (f) the extent to which individuals are willing to take risks when faced with an oncoming train; (g) sensation-seeking tendencies; (h) generally risky, non-train related behavioral practices; (i) knowledge of the laws associated with grade crossings; (j) grade crossing experiences; (k) relevant demographic variables.

The survey was mailed to 1200 Michigan residents aged 15–68 years of age in the eight counties. A total of 891 individuals returned the questionnaires for a response rate of 74%. 36% of the sample was between 15 and 20 years of age. The mean and median age of the sample was 32 years of age.

Results:

- According to the results of the survey, a vast majority of the respondents never engaged in risky behaviors around train crossings.

- If a train was in sight, more than 86% of the respondents said they would 'never' proceed around the gates. But, nearly 14% said they would still go around the gates with the lights flashing even with a train in sight!

- More than 90% of those sampled indicated that they never tried to beat the train across the tracks, nor did they find it exciting to do so. 10% actually thought that trying to beat a train is exciting.

- Males were more likely than females to try and beat the train, consistent with previous literature.

- Risk seekers reported having significantly more trouble seeing the train at night and felt that they had been blocked by a train for an unreasonably long period of time significantly more often when compared with the risk averse. Risk seekers also reported having significantly more close calls with trains and felt that warning flashes generally took too long when compared with the risk averse.

- The authors had some interesting suggestions on ways to reduce the unsafe behavior or risk takers: "The best way to prevent railway accidents may be to prevent (perceived) frustrating experiences for high sensation seekers by providing some 'equally appealing alternative behavior' for them to do if they have to wait for a train to cross. Because they become easily bored and do not like to wait, high sensation seekers need some sort of intervention that engages their attention. Creative solutions are needed to combat the problem. For example, to decrease frustration train schedules can be posted and average delay times can be listed so that drivers can plan their routes. Alternatively, games can be created to act as an 'equally appealing alternative behavior' to engage the high sensation seeker. For example, at particularly dangerous railway crossings electronic systems can be set up where drivers are challenged to ‘test your judgment skills’ by estimating train speed and distance; after a brief time period the answers would flash and then the system would ask another trivia-type question”.

EFFECT OF TRAFFIC CONTROL DEVICES AND WARNING SYSTEMS

8. B.L. Bowman (1987), “The effectiveness of railroad constant warning time systems”, *Transportation Research Record* 1114, pp. 111-122.

Background and Objectives

The majority of train-activated devices now in use are based on track circuits and control logic initially developed approximately 100 years ago, based on an approach track circuit length designed to provide a pre-selected warning time for the fastest train. Trains traveling slower than the design speed or stopping on the approach length result in prolonged activation of the railroad-highway warning system.

Constant warning time (CWT) systems are capable of detecting train speed in addition to train motion, direction, and distance from the crossing. The objective of this study was to determine the effectiveness of railroad constant warning time (CWT) systems in: (1) reducing motorists violation of activated at-grade warning systems, and (2) reducing vehicle-train accidents.

Methodology and Data Collection

For Analysis of Accidents

Four types of crossings were included: flashing lights without CWT (26 crossings), flashing lights with CWT (13 crossings), gates without CWT (39 crossings), and gates with CWT (27 crossings). Accident rates were calculated based on accidents from 1980 to 1984 with the product of the Annual Daily Traffic (ADT) and the number of trains per day, as a measure of exposure.

Driver Behavior

Twelve railroad crossings with 3 in each of the four categories were selected, to study driver behavior. Data were obtained manually with the use of radar guns and stop-watches. Observers noted the time of vehicle arrival for the first vehicle in each lane, the time of violation if the flashers were activated, and the speed of the train.

Results

The accident rate at crossings equipped with CWT systems was in the majority of instances lower than comparable crossings without CWT systems. However, the differences were not large enough to show statistical significance.

CWT systems were found to significantly reduce the number of violations. However, because CWT systems provide a more uniform amount of warning time, result in a greater proportion of violations occurring with smaller clearance time (interval of time between a vehicle clearing the tracks and the time of train arrival) than at crossings without CWT systems. Hence, although the number of violations in crossings with CWT systems is lower, one could argue that violators in these crossings have a higher probability of being struck by a train.

Conclusions

CWT systems are effective in reducing motorist violations of the activated warning devices at the crossing. Crossings with CWT systems also seem to have a lower accident rate compared to crossings without CWT, although the difference is not statistically significant.

9. B.L. Bowman (1987), "Analysis of railroad-highway crossing active advance warning devices", *Transportation Research Record* 1114, pp. 141-151.

Objectives

Determine which one of three candidate active advance warning devices for use on roadway approaches to rail-highway crossings was the most effective.

Methodology and Data Collection

The three candidate devices included: a primary message plate with optional directional arrows, a supplementary WATCH FOR TRAINS message plate, and two 8-in amber, alternately flashing beacons. The study was conducted at four sites where sight restrictions on the approach resulted in an insufficient safe stopping distance. The train detection circuitry at each site was modified to provide train activation of each advance warning device approximately 10 seconds before the activation of the at-grade warning system.

Four railroad-highway crossings in southeastern Michigan were selected as test sites. Each site had sight restrictions that prevented the motorist from observing the crossing on at least one approach. The design used in this project was a modified before-during-after design.

Results

Flashing beacons were effective in reducing vehicle speeds. Statistical analysis performed at the 95% level of confidence between the activated and un-activated states revealed that a significant reduction in velocity occurred during the activated state of the device.

10. K.W. Heathington, S.H. Richards, and D.B. Fambro (1990), "Guidelines for the use of selected active traffic control devices at railroad-highway grade crossings", *Transportation Research Record* 1254, pp. 50-59.

Background and Objectives

In 1986, over 50% of all car-train accidents occurred at crossings with active warning devices, which represent 28.5% of the total crossings. Thus, active crossings are over-represented in terms of number of crashes. Although this apparently high number of crashes may be a result of higher vehicle and train volumes or more complex railroad-highway geometrics at active crossings, it is likely that some of the crashes are caused by motorists either not seeing or not understanding the active warning devices being used. The objective of this study was to provide guidelines for selecting and installing appropriate active traffic control devices.

Results

Results from studies that evaluated the following two devices were summarized: four quadrant gates with skirts and flashing light signals, and highway traffic signals with white bar strobes in all red lenses.

The four-quadrant gate system eliminated violations. Authors argued that if emergency vehicles have to use the specific route, they could simply break the gate arm.

Compared with flashing light signals, the highway traffic signal reduced the number of crossings per signal activation from 3.35 to 0.73, and reduced the risky behavior per train from 0.13 to 0.05 (Risky behavior was defined as vehicles crossing while the flashing light signals are activated and within 10 seconds of the train).

Earl Williams wrote a discussion disagreeing with the authors. Mr. Williams felt that the results may have been due to the novelty effect with traffic signals. The authors responded that the results cannot just be explained by the novelty effect.

11. S.H. Richards, K.W. Heathington, and D.B. Fambro (1990), “Evaluation of constant warning times using train predictors at a grade crossing with flashing light signals”, *Transportation Research Record* 1254, pp. 60-71.

Objectives

To evaluate the effects of train predictors and constant warning time (CWT) on crossing safety and driver response measures

Methodology and Data Collection

A before-after study approach was used to evaluate the impacts of train predictors and CWT on driver behavior and safety. An active crossing in Knoxville, Tennessee, was the field site. Data were collected using portable video recorders.

Measures of effectiveness included:

- *Number of vehicles crossing* – total number of vehicles crossing the tracks between activation of the warning device and the train’s arrival at the crossing
- *Clearance time* – difference in time between the time of the last vehicle’s crossing and that of the train’s arrival.
- *Perception-brake reaction time* – difference in time between activation of the warning device and activation of the vehicle’s brake lights.
- *Speed and Acceleration* – Speed data were collected and a maximum deceleration level was computed.

Results

- The installation of train predictors reduced the average length of train warning time form 75.2 to 41.7 seconds.
- Train predictors and CWT reduced the average number of vehicles crossing the tracks while the flashing light signals were activated from 1086 crossings per 100 train arrivals to 335.
- The predictors reduced the number of vehicles that crossed the tracks within 20 and 10 seconds of the arrival of the train, by more than 50%.
- Predictors did not have any adverse effects on speed profiles, brake reaction times, or deceleration at the test crossing.

12. E.R. Russell (1992), "Innovative passive device studies and demonstrations currently being conducted in the United States and Canada", *Transportation Research Record* 1368, pp. 39-48.

This paper is a review of the literature and gives an overview of the studies of innovative passive devices:

- NCHRP Report 50, 1968: Passive signs that diagrammatically showed the crossing angle were proposed.
- CONRAIL has a YIELD sign written in retroreflective material.
- Arizona – tests of high-intensity retroreflective material. Personnel will spend one day stopping drivers to see what they think of the devices.
- 3M - Promoting the use of diamond-grade retroreflective material on standard crossbucks and posts. Diamond-grade material has about three times the reflective rating of engineering-grade material and about two times the reflective rating of high-intensity, retroreflective material.
- Canada - use of intermediate warning sign that would give a driver additional information about the crossings. This sign would be located between the advanced warning sign and the crossbuck.

13. B. L. Bowman (1993), "Supplemental advanced warning devices", *NCHRP Synthesis* 186, TRB.

This report is a discussion of supplemental advanced warning devices. Included are results of a survey that was conducted to find out about non-standard signs.

14. D.B. Fambro (1998), "Recommended Devices and Applications for use at Rail-Highway Grade Crossings: Working Paper No 5", Texas A & M University, College Station, Texas, October.

<u>Background</u>

This report has a detailed literature review of previous studies conducted as part of a large project funded by the federal government. Working paper 5 provides results of the focus group study and the recommendations.

Methodology

Focus group technique was used to evaluate eight promising devices for improving driver behavior at rail-highway intersections.

Results and Recommendations

- Passive grade crossings in rural areas are ideally suited for rumble strip installations due to driver behavior induced by traveling on roadways with low traffic volumes and infrequent traffic control devices, i.e., inattention to the driving task.
- Passive grade crossings in rural areas are ideally suited for the BUCKEYE CROSSBUCK installation due to driver behavior induced by traveling on roadways with low traffic volumes and infrequent traffic control devices, i.e., inattention to the driving task.
- Passive grade crossings in rural areas are ideally suited for YIELD TO TRAINS signs due to driver behavior induced by traveling on roadways with low traffic volumes and infrequent traffic control devices, i.e., inattention to the driving task.
- Passive grade crossings in rural areas are ideally suited for illumination due to the generally dark conditions at these crossings.
- Vehicle-activated strobes are short, intense burst of light which are flashed when vehicles pass over detectors in the roadway. Their purpose is to focus driver's attention to the advance warning sign and alert them that their vehicle is approaching a decision point of critical importance to safety. Passive grade crossings in rural areas are ideally suited for vehicle-activated strobe light installations due to driver behavior induced by traveling on roadways with low traffic volumes and infrequent traffic control devices, i.e., inattention to the driving task.
- Low speed crossings in industrial areas and low speed crossings on high volume urban roadways on light rail lines are ideally suited for highway traffic signals.

15. D.A. Noyce and D.B. Fambro (1998), "Enhanced traffic control devices at passive highway-railroad grade crossings", *Transportation Research Record* 1648, pp. 19-27.

Background and Objectives

According to a 1995 FRA report, approximately 100,000 crossings in the USA are considered passive crossings – these crossings employ signs and pavement markings to identify and direct attention to the location of the crossing. In 1994, more than 2000 crashes occurred at public passive highway-railroad grade crossing resulting in 239 fatalities. Driver error may result from failure to perceive that a train is in hazardous proximity to the grade crossing. Alternatively, the driver may detect the train but erroneously decide that adequate time is available to clear the crossing. This study was conducted to evaluate the effectiveness of vehicle-activated strobe light and supplemental sign as enhancements to the railroad advance warning sign at passive grade crossings.

Methodology

An enhanced sign system (LOOK FOR TRAIN AT CROSSING) was installed below the advance railroad warning sign. The full-sized strobe light chosen flashed at 1 million candle power and 90 flashes-per-minute (fpm), well below the 600 to 1200 fpm that can trigger seizures in drivers with epilepsy. A loop detector was used to provide vehicle activation of the strobe light. These loop detectors were placed approximately 170 m upstream of the strobe light location to ensure that the strobe light was operating for a sufficient period of light before the driver was in visual range of the warning signs.

A before-after methodology was utilized. Data were collected on spot speeds. A driver survey was conducted to determine drivers' conspicuity of the flashing strobe light and supplemental sign. Drivers' reaction to the strobe light was also observed.

The before data on spot speeds were collected from November 1996 to February 1997 at 10m, 50m, 100m, 150m, 200m, and 400m, from the highway-railroad grade crossing. The after speed study was conducted in May 1997 at the same locations.

Results

Average speeds on the approaches to the grade crossing were found to be lower after the installation of the enhanced sign system with the greatest speed.

16. H.T. Zwahlen and T. Schnell (1999), "Evaluation of two new crossbuck designs for passive highway-railroad grade crossings", *Transportation Research Record* 1692, pp. 82-93.

Objectives:

Study driver response to new crossbuck designs for passive highway-railroad grade crossings. Specifically, look at the impact of the different designs on: (1) driver risk-taking behavior, (2) accident reduction potential, (3) user acceptance, and (4) photometric performance at night.

Methodology and Data Collection:

duction near its location on the approach. For example, average night speeds were reduced by 13% at the 100 m study location on one of the approaches, although it is difficult to predict how much of the reduction is directly due to new sign system.

Thirty-three drivers were surveyed. 52% indicated that they noticed something different about the crossing – apparently this is more than the 20% of drivers in a previous study that were able to recall the standard railroad advance warning sign. All the drivers surveyed indicated that the strobe light was probably meant to introduce additional caution as they approached the crossing.

Two new crossbuck designs were tested along with the standard crossbuck design. The standard improved crossbuck design consists of a wooden post that is reflectorized on all four sides and aluminum blades that are reflectorized front and back. The buckeye crossbuck design consists of a wide center section showing a framed red YIELD legend and two wide side panels that are bent away 45 degrees from approaching motorists. The side panels have the potential to redirect a portion of the light of an oncoming train toward an approaching motorist and a portion of the light from the automobile headlights toward the approaching train, thus providing additional presence information to both the motorist and the train engineer.

Motorist near-collision and violation video data were collected along 4 selected rail corridors during 1995 under the before condition. Near collisions were non-compliant vehicles clearing the tracks with less than 2 seconds before the arrival of the train. Violations are non-compliant vehicles that cleared the tracks with more than 2 seconds before the arrival of the train. The video taping runs were repeated along the exact same rail corridors under the after condition during the late 1996 and early 1997. Half of the old crossbucks in Ohio were replaced with the Buckeye crossbuck and the other half were replaced with the standard improved crossbuck before the after condition. A total of 3,833 approaches to passive RRX were recorded along the four selected rail corridors.

Ten year accident history data were compiled in order to assess the effectiveness of these new designs on the number of crashes.

A set of user acceptance questionnaires was developed to determine the subjective preference for the three crossbuck designs being evaluated as part of this project. The survey pursued a number of goals: (1) determine if road users perceive passive railroad crossings as a hazard, (2) determine self-reported driving behavior at passive railroad crossings, and (3) determine which of the three crossbuck designs is preferred by the surveyed user groups.

Results:

- The video data did not reveal any near collisions. The Buckeye crossbuck provided for slightly fewer violations than the standard improved crossbuck.
- Accident data did not reveal any definite patterns.
- Most people who responded to the questionnaire survey preferred the Buckeye crossbuck over the standard improved crossbuck.
- The fact that all four sides of the post and both sides of the blades of the new crossbuck designs are full reflectorized appears to be of great advantage to a nighttime motorist who is approaching a passive railroad crossing that is already occupied with a passing or standing train.

ANALYSIS OF CRASHES AT RAILROAD GRADE CROSSINGS

17. W.D. Berg, K. Knoblauch, and W. Hucke, (1982), “Causal factors in railroad-highway grade crossing accidents”, *Transportation Research Record* 847, pp. 47-54.

Background and Objectives

This study examined the contributing factors of rail-highway grade crossing accidents. Only crossings that had flashing light or crossbuck warning devices were investigated.

Methodology and Data Collection

79 vehicle-train accidents in Wisconsin and North Carolina were reconstructed and analyzed for patterns of driver and contributing factors. A vehicle-train accident was characterized in terms of an event sequence that led to the collision.

In Wisconsin, a random sample of 22 flashing-light crossings (with 24 accidents in 1978 and 1979), and 14 crossbuck crossings (with 16 accidents in 1978 and 1979), were selected. In North Carolina, 19 flashing-light crossings (with 19 accidents in 1978 and 1979), and 20 crossbuck sites (with 20 accidents) were chosen.

Results

Crossings with Flashers

33-44% of accidents investigated were associated with some form of driver recognition error, and 53-71% were attributed to some form of decision error. The most frequent recognition error involved a driver's failure to detect the presence of either the signal or the train. For many of those accidents where recognition error was a contributing factor, external distractions such as visual clutter, heavy traffic, adjacent intersections, multiple lanes, rough crossings, and slippery pavement, were present.

In the majority of accidents where decision errors were noted, extended signal warning times exceeding 30 seconds were involved. Warning times provided for the accident-involved trains were found to average about 70 seconds and ranged up to almost 9 minutes. In most cases, the extended warning time was due to low-speed trains with a track circuit that is designed for high-speed operations. Limited quadrant sight distance was also an issue with some of these accidents.

Crossings with Cross-bucks

77-85% of accidents involved errors of driver recognition. Of these, 22-25% involved late recognition of a train that was already on the crossing. Errors of driver recognition of an approaching train were primarily due to either limited quadrant sight distance or low driver expectancy associated with very low train volume. For those accidents, where the train was already in the crossing, the primary contributing factors were: (1) limited visibility due to darkness, and (2) roadway alignment restricted the visibility of the crossing.

Conclusion

In crossings that have flashers, the credibility of the warning device is a more important problem than its conspicuity. Lack of credibility occurs because of unnecessarily long warning times. In crossings with crossbucks, driver failure to recognize the presence or approach of a train was the most common problem. The potential contributing factors were low driver expectancy of a hazard and inadequate quadrant-sight distance.

18. J.A. Halkias and L. Blanchard (1987), "Accident causation analysis at railroad crossings protected by gates", *Transportation Research Record* 1114, pp. 123-130.

Objective

Identify probable causes and factors responsible for accidents occurring at railroad crossings protected by gates.

Methodology and Data

The National Rail-Highway Crossing Inventory file and the Railroad Crossing Accident/Incident data file from January 1, 1975 to December 31, 1984, were obtained from the Federal Railroad Administration. Unfortunately, no human factor data were directly available from the file. The analysis was done in two parts: (1) an accident classification system by circumstance, and (2) an analysis of the accidents that remain unexplained by the circumstance.

Results and Conclusions

- Majority of accidents occurred during good weather and good visibility conditions
- Physical and environmental conditions are not sufficient to explain accidents.
- Based on a study of warning times, the authors concluded the following:
- Inconsistency in warning time length leads motorists to distrust signals. At railroad crossings that have a narrow typical warning time distribution, most of the accidents occur beyond the typical maximum warning time.
- Extended warning times lead motorists to ignore warning signals and cross the railroad

OTHER

19. B.L. Bowman, K. Stinson, and C. Colson (1998), "Plan of action to reduce vehicle-train crashes in Alabama", *Transportation Research Record* 1648, pp. 8-18.

Background

The Alabama Department of Transportation was directed by the Alabama Legislature to conduct a comprehensive study of railroad crossings in Alabama and propose solutions to reduce crashes at these locations. This paper gives an overview of the engineering, economic, education, enforcement, and emotion impediments to increase rail-highway intersection safety.

Some Findings and Observations

- Since the frequency of railroad crashes is very low, enough attention is sometimes not paid to these events

- No one pays attention to railroad crossings safety unless there is a serious incident. For a while, drivers, especially in the community in which the tragic crash occurred, are more cautious when approaching and crossing railroad tracks

- Mass media should constantly stress consequences of vehicle-train crashes

- Sufficient funds are not available in rural States to implement flashing lights and gates at crossings

Need to have enforcement personnel on both sides of the crossing. In addition, enforcement personnel have indicated that they often dismiss tickets issued to violators of grade crossing laws because they consider the stop sign to be installed on the railroad's private property, and hence, not enforceable by a public agency.

Appendix B

Driver Perception Experiment Instruction

Introduction:

Thank you for participating as a subject in this *Human Factors in Traffic Safety* experiment. You will be watching 24 video clips (ranging from 15 to 25 seconds each). The objective of the experiment is to obtain your perception and responses (as a driver) to various traffic conditions. You can watch the same video clip **<u>no more than twice</u>**. After having watched each video clip you will proceed to answer questions.

Task Procedure:

1. Get familiar with the buttons on the screen.
2. Watch the video clip. Repeat the video once if necessary.
3. Click the "Next Question" button to answer questions.
4. Repeat Procedure 2 and 3 until finish all 24 trials.

Duration:

The entire experiment will last for approximately one hour.

You have small breaks between the trials. Please ask if you have any questions.

Appendix C

Questions for Video Clips in the Driver Perception Experiment

1. Which devices have you observed in the video?
    a. Advance Railroad Crossing
    b. Tracks parallel to road
    c. Light rail
    d. Pavement Railroad marking
    e. Crossbuck
    f. Exempt
    g. Stop
    h. Flashing lights
    i. Gates with flashing lights
    j. Traffic signal
    k. None

2. What should you do at this point?
    a. Slow down
    b. Speed up
    c. Continue with the same speed
    d. Stop

3. What changes do you expect in the status of the signs at this crossing if a train is approaching?
    a. Steady red light
    b. Flashing red
    c. Gates down
    d. No changes

4. If a train were approaching from behind what would you do in a situation like that?
    a. Stay in the lane and expect the train to stop
    b. Move to the right lane for the train to pass

5. What is the next step in such a situation?
    a. Stay in the current lane behind the truck
    b. Move to the left lane towards the tracks
    c. Perhaps you took the wrong turn

6. What is the next step you will take in such a situation, if you see a train is approaching?
    a. Stop for the train to pass
    b. Continue driving because the train will stop at the light

7. How many numbers of railway tracks did you cross?
   a. 1
   b. 2
   c. More than 2
   d. None

8. The “STOP” sign indicates that you should stop for
   a. The trains
   b. The vehicles running along the main road in front of you
   c. Both, the trains and the vehicles

9. The “EXEMPT” sign for the crossing indicates that you should
   a. Slow down when crossing
   b. Stop, check and then proceed
   c. Continue driving with the same speed
   d. Ignore because the railroad crossing is inactive

Appendix D

Simulated Driver Test

Subject ID: ________

1. (   ) All drivers should be aware that the following vehicles must stop at a railroad crossing before proceeding:
    a. school buses, passenger buses, and trucks carrying hazardous materials
    b. motorcycles, mopeds, and bicycles
    c. ambulances and fire engines
    d. None of the above

2. (   ) If the red lights at the railroad crossing continue to flash even one minute after a train has passed, it is most probable that:
    a. there may be another train coming.
    b. the lights are malfunctioning.
    c. it is just the delay of the lights in turning off.
    d. none of the above

3. (   ) Which of the following statements is NOT TRUE?
    a. Light rail trains will always use horns when approaching railroad crossings.
    b. Light rail vehicles are very quite.
    c. Light rail trains will stop for red lights.
    d. Light rail trains may share the same lane of a road with other vehicles.

4. (   ) Which of the following statements is TRUE about flashing red light at railroad crossings?
    a. A flashing red light at a railroad crossing functions the same as a stop sign at intersections.
    b. A flashing red light at a railroad crossing functions the same as a steady red traffic light at intersections.
    c. A flashing red light at a railroad crossing functions the same as a flashing red light at intersections.
    d. None of the above statement is TRUE.

5. (   ) When a lane is shared by vehicles and light rail trains:

   a. Vehicles should always avoid staying in front of light rail trains.
   b. Light rail trains always have the right of the way.
   c. Vehicles always have the right of the way.
   d. Both vehicles and light rail trains have the same right.

6. (   ) You are approaching an intersection controlled by a flashing red light. You should:

   a. slow down and drive carefully through the intersection.
   b. get ready to turn right or left, because the road is closed ahead.
   c. merge to the right.
   d. stop at the intersection, then proceed as traffic allows.

7. (   ) If your vehicle stalls on a crossing immediately get out of your car. In such conditions, if you see a train coming, you should

   a. go back and try to start the vehicle as best as you can to avoid an accident.
   b. get away from the tracks and run in the travel direction of approaching train at an angle away from the train.
   c. get away from the tracks and run toward the approaching train at an angle away from the train.
   d. turn on vehicle headlights and press horns to signal the train to stop.

8. (   ) You are coming to an intersection with a steady yellow light. You should:

   a. prepare to stop; the light is about to turn red.
   b. turn around, the intersection is closed.
   c. drive carefully through the intersection.
   d. continue driving in order to avoid rear-end collisions.

9. (   ) Identify the following marking on the road:

   a. no entrance
   b. railroad crossing
   c. rough road
   d. dangerous intersection

10. (   ) Identify the Sign –

a. Bridge Ahead
b. No Trucks
c. Object Marker
d. Low Clearance

11. (   ) You are driving on a road   with two or more lanes traveling in the same direction. You should:

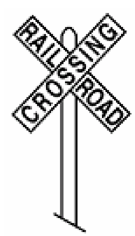
a. drive in any lane.
b. drive in the left lane.
c. drive in the right lane if you are under the speed limit, in the left lane if you are driving over the limit.
d. drive in the right lane, except to pass.

12. (   ) When the light rail crossing is controlled by regular Red-Yellow-Green lights:

a. Follow the lights.
b. Light rail trains will active the traffic lights to turn RED when it approaches the crossing area.
c. Vehicles always have the right of the way.
d. Light rail trains always have the right of the way.

13. (   ) The crossbuck sign at railroad crossings for drivers functions similarly as a ______ at some road intersections:

a. STOP sign
b. YIELD sign
c. ONE WAY sign
d. DO NOT ENTER sign



14. (   ) Drivers should be aware of motorcycles and bicycles upon driving through railroad crossings because:

a. motorcycles and bicycles may slow down at railroad crossings.
b. motorcycles and bicycles may lose balance at railroad crossings.
c. motorcycles and bicycles may change their course in order to cross the tracks at an angle perpendicular to the tracks.
d. all of the above.

15. (   ) It is important to slow down:

a. on narrow or winding roads.
b. at intersections or railroad crossings.
c. when the road is wet or slippery.
d. all of the above.

16. (   ) If a train and a car are both traveling at 55 mph and brakes are applied at the same time, which vehicle will come to a stop in a longer distance?

a. Car
b. Train
c. Both will come to a stop at the same distance
d. Depends upon visibility.

17. (   ) Why is driving in the city considered more dangerous than highway driving?

a. Speed limits are lower.
b. Driving lanes are very narrow.
c. Cross traffic and pedestrians create hazards.
d. Road conditions are worse in bad weather.

18. (   ) When should you stop for a stopped school bus?

a. All of the time.
b. When its red lights are flashing.
c. Only in school zones.
d. On week days while school is in session.

19. (   ) You are approaching an intersection that has a stop sign, a stop line and a cross walk. Where should you stop your vehicle?

a. At the corner.
b. At the crosswalk.
c. At the stop line.
d. At the stop sign.

20. ( ) If you are approaching a railroad crossing that is not controlled by any signals, gates, and flashing lights, you should

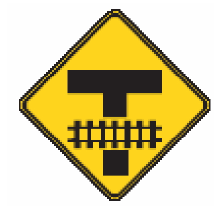
a. not worry, as trains rarely pass through that crossing.

b. be extra cautious and slow down, as trains may approach at any time.

c. speed up and cross the tracks as soon as possible, as trains may approach at any time.

d. avoid driving through such crossings.

21. ( ) The sign shows that:



a. a railroad runs parallel to the road that you are on.

b. the road is broken (interrupted) by a railroad.

c. you are going to pass a railroad and a road which run parallel and are separate in a short distance.

d. there is an overpass or underpass for you to cross the railroad tracks.

22. ( ) Do not park on any railroad tracks or within _____ of the nearest rail of a railroad crossing.

a. 15 feet.

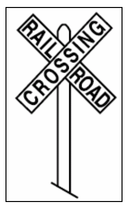
b. 30 feet.

c. 50 feet.

d. 100 feet.

23. ( ) Following are some of the signs that you may find while approaching a railroad crossing. The order in which you will see these signs as you are approaching that railroad crossing is:

(1)



(2)

(3)

a. (2)-(1)-(3)

b. (1)-(3)-(2)

c. (2)-(3)-(1)

d. (1)-(2)-(3)

24. ( ) If the gates start to come down while you are driving across railroad tracks at the grade crossing, you should:

a. continue driving to pass the crossing.
b. stop immediately, no matter where you are.
c. back up the vehicle in order not to be trapped within the gates.
d. make turns to drive around the gates.

25. ( ) When you see the following signs upon approaching railroad crossings, it means:

a. You should not use the crossing.
b. The railroad is inactive, therefore keep driving without hesitation.
c. The crossing is not controlled by any signals, flashing light, or gates.
d. There is an overpass or underpass to use.

26. ( ) Identify the Sign –

a. Railroad Crossing
b. Three Way Intersection
c. Merging Traffic
d. Side Road with Rail Crossing

27. ( ) The NO TRAIN HORN sign shows to drivers that:

a. the driver of the vehicle should not use the horn unless it is necessary.
b. the engineer of the train will not use the horn unless it is necessary.
c. the driver of the vehicle many not be able to hear the horn even if the driver of the train uses the horn.
d. the engineer of the train may not be able to hear the horn even if the driver of the vehicle uses the horn.

28. ( ) If you reach a railroad crossing which has no gates, but red lights are flashing, you should:

a. remain stopped until the lights stop flashing.

b. stop, check, and go.

c. slow down to proceed through the crossing.

d. proceed through the crossing if no trains are visible.

29. ( ) To pass a large truck, you must:

a. make sure you have room to complete the maneuver without excessive speed.

b. pass on a down grade.

c. honk and flash your lights to make the truck driver aware of your intentions.

d. all of the above.

30. ( ) The proper sequence prior to making a left turn from a four-lane highway is:

a. shift to the proper lane and slow down, activate the turning signal lights, wait for the traffic from the opposite direction to clear.

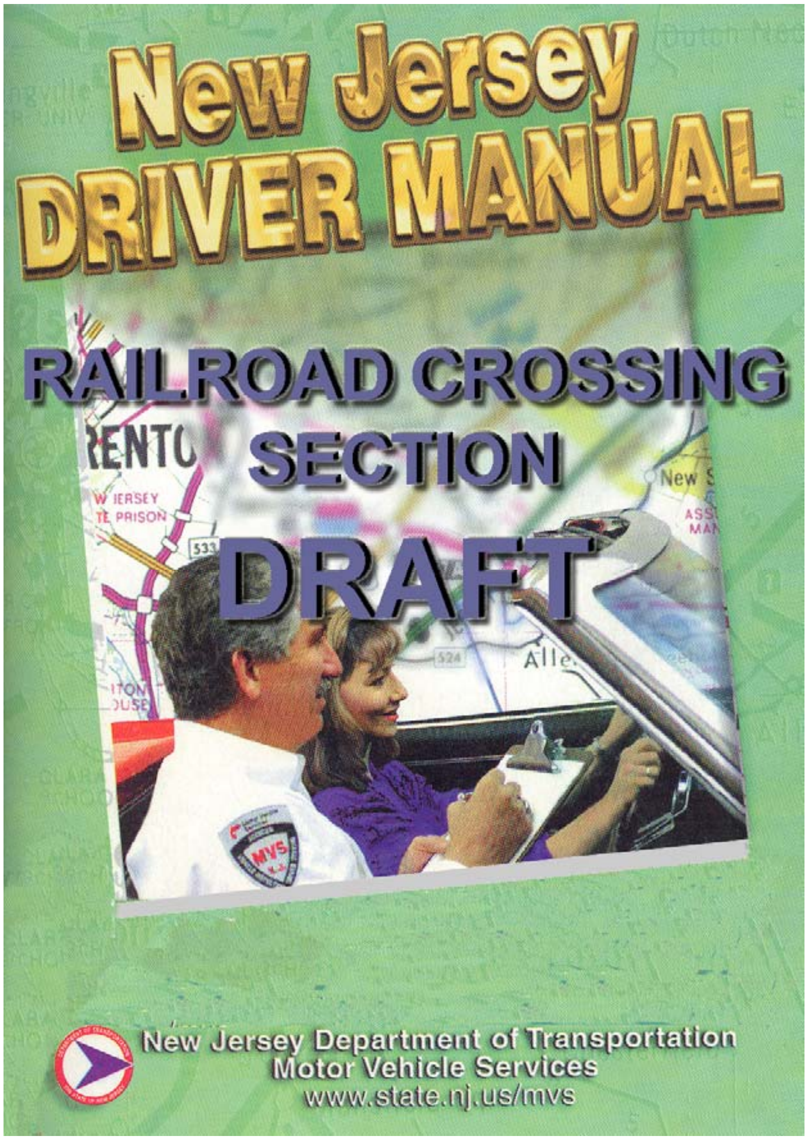
b. activate the turning signal lights, wait for the traffic from the opposite direction to clear, shift to the proper lane and slow down.

c. activate the turning signal lights, shift to the proper lane and slow down, wait for the traffic from the opposite direction to clear.

d. wait for the traffic from the opposite direction to clear, shift to the proper lane and slow down, activate the turning signal lights.

Appendix E

Draft Railroad Crossing Section for New Jersey Driver Manuals

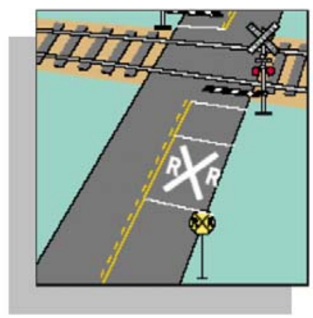


Part 8. Railroad Crossings

Sharing the road with trains

It is important to remember that trains always have the right-of-way, THAT'S THE LAW. If you are walking or driving, you may be able to stop suddenly. However, a train cannot stop suddenly or swerve to avoid you. A train traveling at 55 mph can take a full mile to stop. While an average car weighs 3000 pounds, an average loaded train weighs 12 million pounds. You are 30 times more likely to die in a collision with a train that in a crash with a car or truck.

Railroad warning signs, signals, and devices



All crossings in New Jersey are marked with one or more of the following warning signs, signals, and devices. Some crossings have flashing lights, gates, and or bells to warn you of approaching trains. At other crossings, it is your responsibility to watch for trains and cross only when it is safe to do so.

Advance warning sign

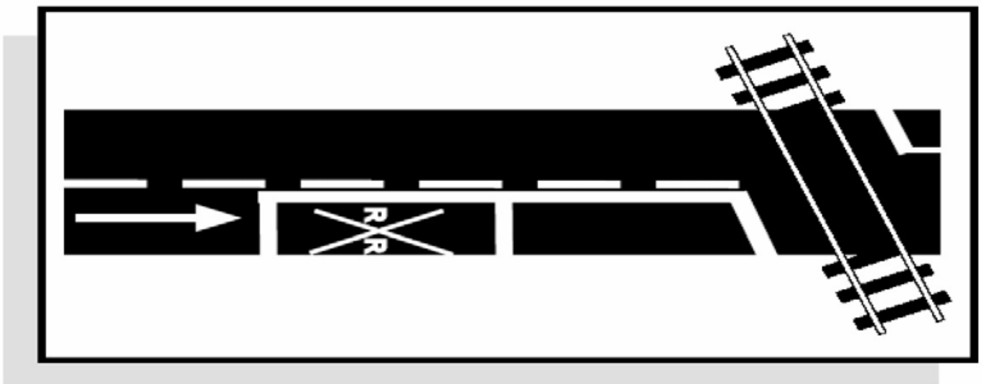
Advance warning signs mean a highway-rail crossing is ahead. The signs are located far enough from the crossing to allow you to stop before reaching the crossing, if necessary.

At some crossings, this advance warning sign is supplemented by one of the following two signs to indicate that the crossing that you are approaching is not controlled by any signals, flashing lights, or gates.

At these crossings, it is your responsibility to watch for trains and cross only when it is safe to do so.

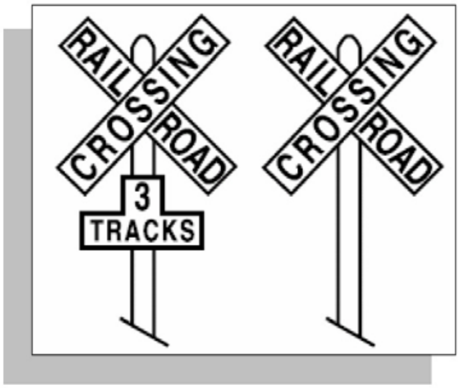
Pavement markings

As you approach some crossings, an R X R and a stop line may be painted on the pavement in front of the crossing. While you wait for a train to pass the crossing, always stay behind the stop line.



Railroad crossbuck signs

Crossbucks are found at most crossings. Treat these signs as YIELD signs – slow down and prepare to stop if you see or hear an approaching train. In some crossings, if there is more than one track, the number of tracks will be shown below the crossbuck sign.



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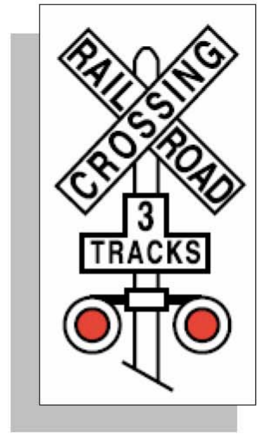
Crossbucks with red flashing lights

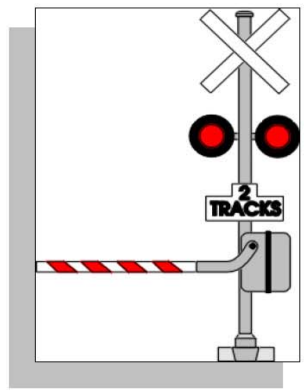


When the lights are flashing that means a train is coming. ALWAYS STOP WHEN THE LIGHTS ARE FLASHING. CROSS ONLY WHEN THE LIGHTS STOP FLASHING.

Flashing red lights at a railroad crossing are similar to a circular red signal at an ordinary traffic signal – you are expected to stop until it is turned off. This is in contrast to flashing red lights at roadway intersections, where they work like a stop sign.

It is important to understand that even after a train has passed the crossing, the lights may continue to flash if another train is approaching the crossing from the opposite direction.

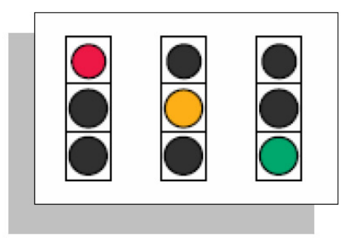
Crossbucks with red flashing lights and gates



Stop when the lights begin to flash and gates start coming down. DO NOT DRIVE AROUND THE GATES. CROSS ONLY WHEN THE LIGHTS STOP FLASHING AND THE GATES ARE RAISED.

Traffic signals at railroad crossings

Some railroad crossings in New Jersey are controlled by ordinary traffic signals. When you approach such a crossing, a circular green signal means that you can "go" through the crossing without stopping, a circular yellow signal means "caution", and indicates that the signal is about to turn red. A circular red signal means that you have to "stop", and wait for the signal to turn "green" before proceeding through the crossing.



Quiet Zones

In some areas, trains are prohibited from blowing their whistles (horns) as they approach the crossing. You will see the sign shown here as you approach the crossing:

The lack of the train horn indicates that additional caution is required in negotiating this crossing.

SAFETY TIPS

Here are some safety rules to keep in mind while approaching a railway crossing:

Be patient. Some drivers and pedestrians try to beat the train because they do not want to wait the 30 seconds to 2 minutes average time it takes for the train to pass through the crossing. NEVER TRY TO RACE A TRAIN. If you lose the race, you will not have a second chance. Because of the large size of a train, it appears to be moving much slower than you think.

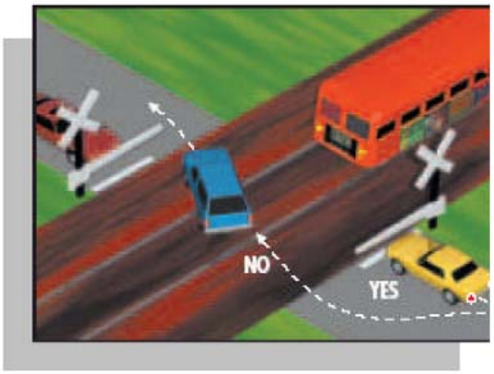
Do not be negligent. When some drivers or pedestrians see railroad crossing sign or warning, they do not respect the potential for danger. It is important that you look, listen, and be prepared to stop while crossing the railroad tracks. If your view of the tracks is blocked, slow down and proceed with more caution than normal.

Expect a train at any time. Trains do not always run on a schedule. That is why it is important to expect a train to cross at any time.

Familiar crossings without much train traffic can be the most dangerous. If you often use such a crossing and do not usually see a train, you may start to believe that trains never go by. Believing this can be dangerous.

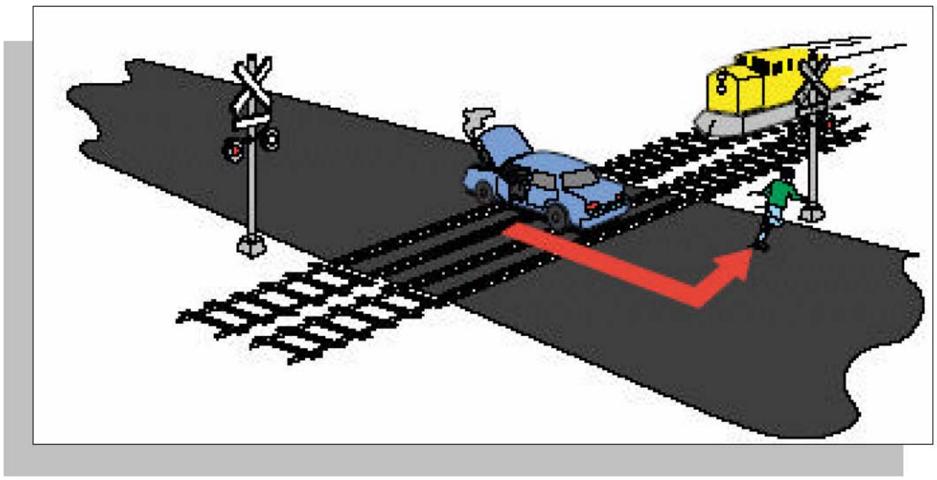
Do not get trapped on railway tracks. Never move onto a railroad track unless you are certain that you can drive across safely. Once you have started across the tracks, keep going, especially if you see a train approaching.

Never shift gears. If your vehicle has a manual transmission, shift down before reaching the tracks. To avoid stalling, you should not change gears while crossing the track.

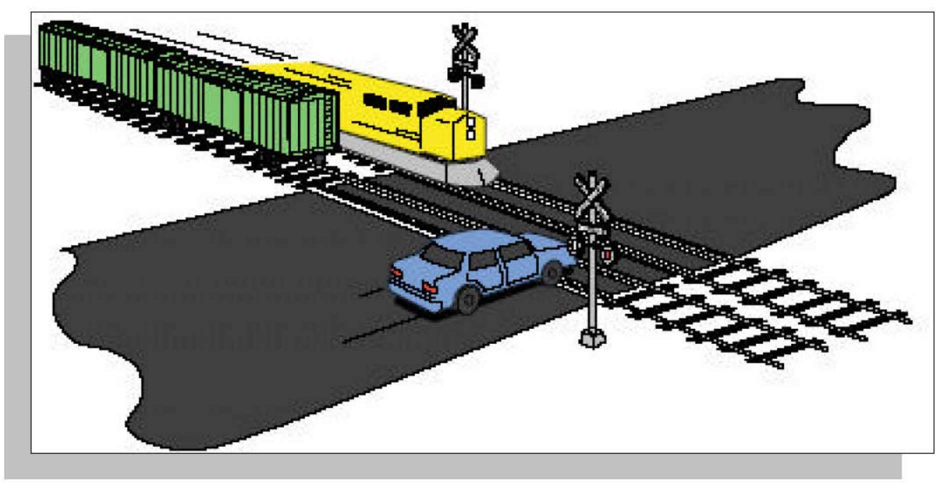


Never drive around gates. If the gates are down, stay in place and do not cross the tracks until the gates are raised and the lights stop flashing. However, if you happen to be crossing the tracks and the warning lights begin flashing or gates start to come down, do not stop, KEEP MOVING! The warning signals will allow enough time for you to finish driving through the crossing before the train arrives. The gate on the far side of the tracks will not block you in. If you stop and try to back up, your vehicle may stall.

Get out of your vehicle if it stalls. If your vehicle stalls on a crossing, immediately get out of the vehicle and off the tracks. If a train is coming, get away from the tracks and RUN TOWARD THE APPROACHING TRAIN at an angle away from the train. By moving toward the train, you will not be hit by approaching debris. Remember, YOUR CAR IS REPLACEABLE, BUT YOU AREN'T.



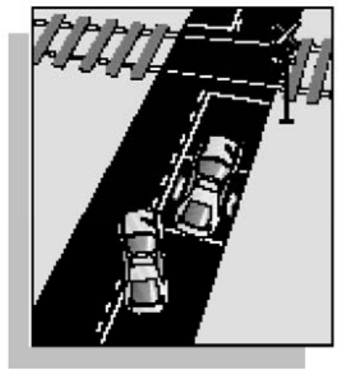
Watch out for the second train. When you are at a multiple track crossing and the last car of a train passes by, do not proceed until you are sure no train is coming on another track, especially from the opposite direction.



Watch for vehicles that must stop at crossings. School buses, passenger buses, and trucks carrying hazardous materials must stop at all railroad crossings before proceeding. Be prepared to stop if you are following these vehicles.

Be more careful at night. It is very hard to judge a train's speed and distance at night. Do not assume that a train is not coming just because you do not see any light. Slow down or stop and look before crossing the tracks.

Never pass at a railroad crossing. Do not pass vehicles or bicyclists at or near railroad crossings. It is possible that vehicles and bicyclists may lose control of their vehicles at the crossing due to uneven surfaces and gaps between the track and the pavement. Passing vehicles at railroad crossings can result in a collision.



Do not park at or near railroad crossings. Do not park on any railroad tracks or within 50 feet of the nearest rail of a railroad crossing. If you park near railroad tracks, it may prevent other motorists from being able to clearly see an approaching train.

Use additional caution in highways that are close to railroad crossings. In some locations, when you are close to a railroad crossing, you may see one of the following signs:

These signs indicate that you are traveling on a road that is very close to the railroad tracks and also parallel to it. Be careful as you approach these locations, especially if you are planning to make a turn.

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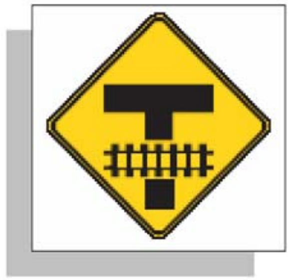
Intersections very close to railroad crossings can cause some confusion to motorists. In some locations, you may see one or both of the following two signs:



As you approach these intersections, it is important that you do not get stuck on the railroad tracks because of a queue. Slow down and make sure that you do not make the mistake of turning onto the railroad tracks instead of turning onto the highway that is parallel to the tracks. Never move onto a railroad crossing unless you are certain that you can drive across safely.

Sharing the road with light rail vehicles

Light rail vehicles and crossings

Light rail transit is a mode of metropolitan transportation that employs light rail transit vehicles (commonly known as light rail vehicles, streetcars, or trolleys) that operate on rails in streets. In some areas in New Jersey, light rail vehicles (LRV's) operate on streets in the same way as other motor vehicles, and will have the same rights and responsibilities as other motorists. Under these conditions, other vehicles share a lane with light rail trains. However, in other areas, LRV's may operate in the opposite direction from other traffic. The LRV's will be governed by all traffic signals and signs when operating on the streets.

The following sign indicates that you are approaching a light rail crossing.

Look and listen for a train, and cross the tracks only when it is safe to do so. Some light rail crossings may have gates and flashing lights. Obey these signals as you would at any railroad crossing.

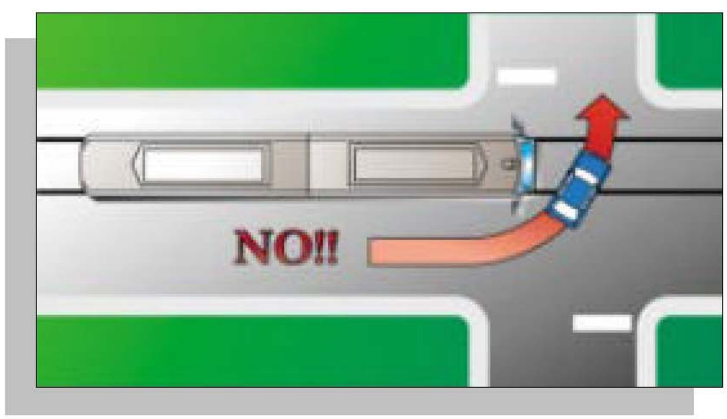
In some roads, certain lanes may be restricted for use exclusively by LRVs. In such cases, the following signs will be indicate which lanes will be used by LRVs:

Pedestrian safety tips

- LRV's are very quiet so when approaching a light rail line stop, look, and listen in both directions (even on one way streets).
- Do not step on the rails as they can be very slippery.
- Never climb between two LRV's that are hooked together.

Driver safety tips

- Never turn in front of an approaching LRV.



9

- Never turn across a set of light rail tracks without checking in all directions.
- Watch for people getting on and off a stopped LRV.
- Pay particular attention to these special traffic warning signs in connection with light rail

- Be especially alert in light rail areas as nearby buildings and foliage can make it difficult to see them.
- The light rail crossing areas for motorists can have regular traffic lights. Some have warning lights and some have gates.

Answers:
1-d, 2-b, 3-c

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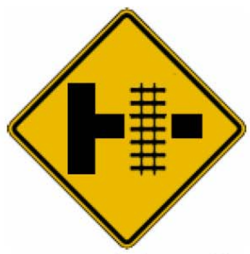
Study questions for Part 8

1. Identify the Sign –



a. three way intersection
b. merging traffic
c. railroad crossing
d. side road parallels railroad track

2. You have been waiting at a railroad crossing for more than a minute and the gates are still down and the lights are still flashing. You should:

a. drive around the gates
b. wait for the lights to stop flashing and the gates to be raised before proceeding
c. call the police to determine why the gates are down and lights are still flashing
d. get out of the vehicle and try to determine why the gates are still down and the lights are still flashing

3. Identify the following marking on the road:

a. no entrance
b. rough road
c. railroad crossing
d. dangerous intersection

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