Prior Driver Performance and Expressed Attitudes Toward Risk as Factors Associated With Railroad Grade Crossing Violations

Report Prepared for:

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
RAIL DIVISION

BY

THE UNIVERSITY OF NORTH CAROLINA
HIGHWAY SAFETY RESEARCH CENTER

JUNE 1999

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Acknowlegements

The present research was supported by the Rail Division of the North Carolina Department of Transportation (NCDOT). The NCDOT point of contact for this effort was Mr. Paul Worley. The conclusions and recommendations contained in this report are those of the HSRC Principal Investigator, Dr. Ron Hughes, and not necessarily those of the NCDOT. HSRC data base and statistical analysis support were provided by Mr. Eric Rodgman and Dr. Richard Stewart, respectively.

Prior Driver Performance and Expressed Attitudes Toward Risk as Factors Associated With Railroad Grade Crossing Violations

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EXECUTIVE SUMMARY

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' perceptions of the risks associated with grade crossing actions and similar actions at signalized intersections. Risk perception attributes of violators were *inferred* from relationships identified in the general user sample between driver history data and responses to the risk perception questionnaire.

From the driver history data, it was determined that 'violators' were over-represented in the age ranges of 16-30 and 31 to 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. Possible *trends* between the probability of grade crossing violations, prior traffic convictions**,** and prior crashes were identified but could not be substantiated at the level of statistical significance adopted for the present study. In terms of the general user sample's responses to questionnaire items dealing with knowledge of train and grade crossing operations, risk perception, and the factors used in judging the risk at grade crossings and other similar traffic situations (e.g, surface intersections), broad individual differences were noted. The most extreme responses were often correlated with prior driving histories characteristic of those associated with drivers in the 'violator' group. In general, the present data suggest 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.'

Were future research to confirm the reliability of these findings, it is not clear what would constitute effective countermeasures for dealing with the behavior(s) in question, short of more effective measures (e.g, quad gates, median barriers, etc.) for physically prohibiting the behavior from occurring combined with methods (e.g, photo-based enforcement) to circumvent problems with traditional manpower-intensive enforcement methods.

In partial defense of the behavior in question, the report also discusses how the acquisition and maintenance of such behaviors may be linked to inconsistencies between the signals used to warn

drivers at grade crossing locations and the presence of the threat with which these signals are intended to be correlated. In the absence of a high degree of signal/threat correlation, signalization loses its effectiveness, especially when a segment of the user population perceives signalization to be ‘advisory’ as opposed to regulatory in nature and whose behavior may also, in part, be motivated by the very risk which most drivers seek to avoid.

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Background

The North Carolina Department of Transportation has a comprehensive, proactive rail effort underway in the areas of safety and higher speed rail planning. In addition, the NCDOT plays a lead role in coordinating high-speed rail activities among the southeastern states along the Federally designated Southeast Corridor.

On the *Sealed Corridor* project, which is the first of its kind in the United States, the Department takes a corridor approach to the testing of new technologies. The *Sealed Corridor* is a joint effort of the North Carolina Department of Transportation and the Norfolk Southern Corporation. The project has been funded through a partnership with the Federal Railroad Administration and the Federal Highway Administration. A significant portion of this effort involves attempts to think "outside the box" and to develop solutions that enhance the existing warning devices at crossings.

Motorists continue to take their chances at crossings - even those that are signalized and have gates – sometimes with tragic consequences. Norfolk Southern's main line between Greensboro and Charlotte over the North Carolina Railroad, is host to high levels of freight traffic, with 44 daily trains from the industrial northeast to the heart of the south. In addition, six passenger trains use this route daily. Historically, this route has a high rate of crossing incidents due to the ever-growing highway traffic in the urban areas along the corridor that crosses the tracks at numerous at-grade crossings. Over the past 12 years, 125 incidents, involving 56 injuries and 31 fatalities have occurred on the corridor.

In 1992, the United States Department of Transportation identified the Raleigh-Greensboro-Charlotte route as one of five nationally designated corridors for State high-speed rail development efforts. On December 1, 1998, USDOT Secretary Rodney Slater designated this route as the "Southeast Corridor" and extended it through South Carolina and Georgia. Under sections 1010 and 1036 of ISTEA and Section 1103[c] and the Next Generation High-Speed Rail program of TEA-21, a total of approximately $9 million has been designated for crossing safety improvements along these corridors.

This funding was used by the North Carolina Department of Transportation and Norfolk Southern to conduct a series of tests at the Sugar Creek Road crossing in Charlotte which is traversed by an average or 23,000 vehicles per day. Using digital camera surveillance, the Department was able to capture moving images of "gate runners." Also, each crossing was equipped with an intelligent signal monitoring system to monitor the performance of each crossing and automatically provide notification of malfunctions.

For twenty weeks, baseline data were collected at the Sugar Creek Road crossing. Median barriers were then installed, followed by 4-quadrant gates, and then finally, 4-quadrant gates with median barriers. Using each of these barrier enhancements, the number of gate running incidents was significantly reduced. For example, median barriers reduced violations by 77%, 4 quadrant gates reduced violations by 86% and 4-quadrant gates with median barriers reduced violations by 98%. Similar results were obtained at a second (Orr Road) crossing in Charlotte,

In August 1998, a digital video ticketing system was placed in service at the Henderson Street crossing in Salisbury, NC. This particular crossing had a history of violations and incidents. In cooperation with local law enforcement and judicial officials, violators were ticketed in a test that was the first of its kind in North Carolina.

As part of this test, the University of North Carolina Highway Safety Research Center was requested to conduct a comparison of driver history records for violators and general users of the Salisbury site, as well as to develop and administer a survey to users of the Henderson St crossing focused on the perception of the risks associated with grade crossing. The following presents the results of these comparisons and a summary of the relationships identified between driver history variables associated with grade crossing violations and their relationship to drivers' perceptions of the risks involved.

Distinguishing 'Violators' from the General Population of Users

During the period of the study at the Salisbury location, there were 64 documented instances where drivers were observed to illegally proceed around the lowered crossing gates as a train was approaching. Evidence of violations was obtained from a photo-based system implemented in conjunction with instrumentation installed at the site by the NCDOT and the Norfolk Southern Corporation. The Henderson St crossing consists of six tracks, on which operate both freight and Amtrak passenger service. The frequency of trains at this location is approximately every 15 minutes throughout the day.

Figure 5. Photo Surveillance Hardware

Figure 1 shows the pole mounted photo instrumentation system that was located on both sides of the crossing. The identity of 'violators' was determined from photographs taken by the instrumentation system of the rear-mounted license plate and photographs taken of the driver through the front window of the vehicle. A driver was identified as a 'violator' only if he/she was detected as passing over a loop in the oncoming lane (i.e., that was to the left of the lowered gate) that was active only when the gate was in the down position. Drivers inadvertently caught on the tracks when the signal was initiated were not considered as violators.

Since the registered owner of a vehicle (as determined from the license plate) need not have been the actual driver of the vehicle at the time the driver was observed, confirmation of the identify of the actual driver (for violators) was determined manually by the Salisbury Police Department. The goal of the HSRC portion of the study was to determine whether this group of ‘violators’ could be distinguished from a sample of the general population of users of the Henderson Street crossing in terms of age, gender, and/or prior driving histories (e.g., in terms of crashes and/or prior violations).

Henderson St “User” Population

Definition of the general user population was based upon a match of registered owners (not necessarily actual drivers) and license plate numbers manually recorded on two different days during daylight hours (generally from 9AM to 4PM) irrespective of the condition of the gate and approaching train. Although the approximate age and gender of the driver was recorded along with the license plate number, there was no attempt to verify that the driver and registered owner were the same individual. Because the observations of those in the ‘user’ group were not restricted to conditions where drivers could either exhibit compliance or non-compliance (that is, under conditions where the gate was down and a train was approaching), it is safe to assume that the user group contains both *compliant* individuals (i.e., consistent non-violators) as well as individuals who, on occasion, might be a ‘*violator*.’

Sample Limited to Passenger Vehicles. Commercial vehicles were not included in the ‘user’ group because of the low probability of the driver and registered owner of the vehicle being one in the same. Only passenger vehicles with North Carolina plates were included in the sample, since access to driver history files was limited to North Carolina drivers. Thus, from approximately 1400 observations, it was possible to identify a sample of 1129 individual (non-redundant) North Carolina drivers against which violator age, gender, and driver history variables could be compared/contrasted with the sample of ‘violators’ identified by the system.

HSRC Questionnaire

As part of the study, a questionnaire was developed by HSRC for use in probing issues related to driver risk perception and risk taking both as they relate to the likelihood of compliance/non-compliance at railroad grade crossings as well as to other similar traffic control situations. The HSRC questionnaire is found in the Appendix of the present report.

The original intent was to administer this questionnaire to both ‘violators’ and to members of the sample of grade crossing users. Waiving the issuance of citations to violators in exchange for completion of the questionnaire was determined by the Institutional Review Board (IRB) at the University of North Carolina to constitute ‘coercion.’ Since voluntary participation of violators proved to be non-existent, questionnaire data are only available for that subset of the general user population who completed the survey (137 of 1127). To motivate participation in the study, the NCDOT and Amtrak offered free round trip tickets to those who completed and returned the questionnaire. Even with this incentive, there was no voluntary participation of ‘violators.’

General Approach and Rationale

The general approach is described below and illustrated in Table 1.

- Compare and contrast drivers in the ‘general user’ and ‘violator’ samples in terms of information contained in their NCDMV driver history files (for example: age, gender, record of prior convictions for traffic violations, and record of crash involvement).

- Characterize the responses of drivers in the sample of general grade crossing users to items on the HSRC questionnaire. The composition of this group is assumed to represent both compliant drivers as well as violators and/or *potential* violators. (Remember that no actual violators voluntarily completed the questionnaire) The focus of the analysis shall be on the *range* of responses to items on the questionnaire, especially on those items implying driver orientation to risk.

- On the basis of trends identified in the analysis of NCDMV driver history files for the general user sample and the violator sample, compare and contrast the questionnaire responses of ‘violator-like’ and ‘non violator-like’ drivers to determine if systematic differences emerge in terms of differential responses to risk related items.

- From results of the driver history analysis and results of the comparisons of violator-like and non violator-like responses to the questionnaire, develop a general ‘profile’ of the grade crossing violator.

- Based upon the results of the study, provide the NCDOT with recommendations for appropriate safety measures at railroad grade crossings.

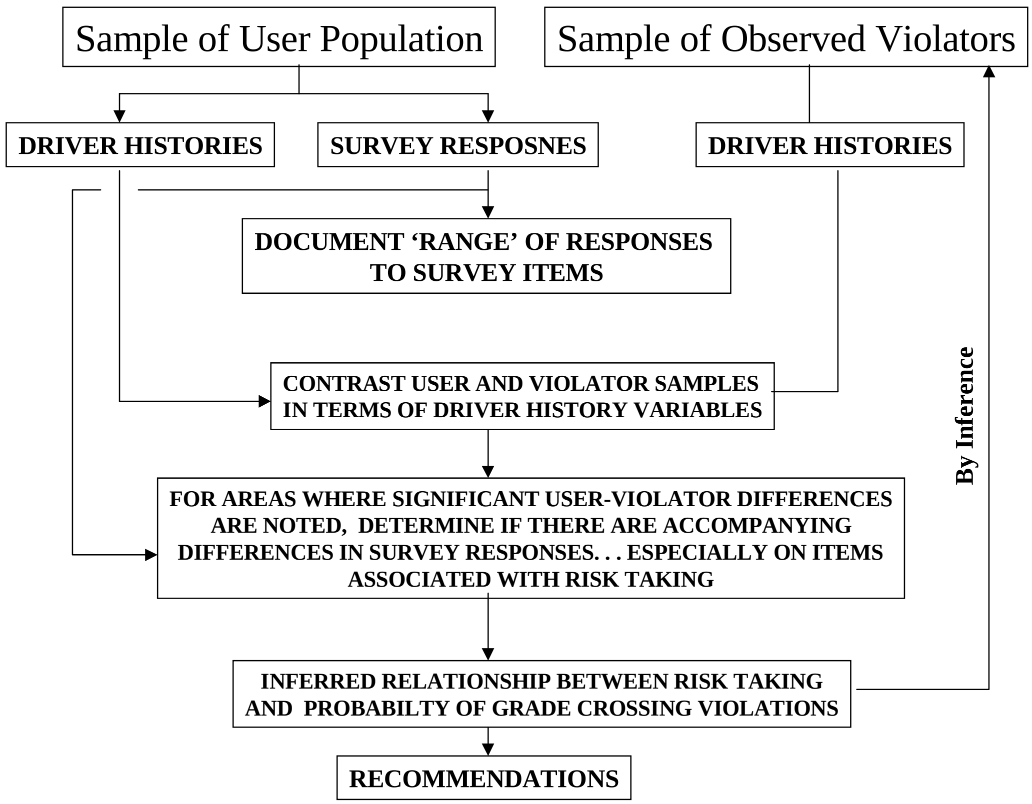


Table 1. Overview of General Approach

RESULTS

Organization of the Results Section

The results are organized into three sections. The first deals with the analysis of driver history data (convictions, crashes, gender, age, etc.) as a function of whether drivers were classed as 'violators' or as members of the general class of Henderson St grade crossing 'users.' The second section provides an overview of driver responses to the HSRC questionnaire. The third section represents an effort to integrate the results reported in the first two sections with the objective being to identify a 'profile' of the grade crossing violator.

Section I. The Driver History Data: Violators Versus General User

Total Convictions

Table 2 summarizes the types of violations (actual convictions) as a percentage of the total number of violations/convictions for the sample of Henderson St 'users' (including 'violators'). Data are for the period 1994-1997. Figure 2 contrasts violators and users at large in terms of the percentage of each group with one or more violations resulting in a conviction. The data show that 27 percent of grade crossing violators had one or more convictions for a traffic violation during this period compared with 19 percent of the sample comprising grade crossing users at large. The difference, while in the expected direction, was not statistically significant at the 0.10 level adopted for the present study ($X^2 = 2.429$, df = 1, p = 0.119).

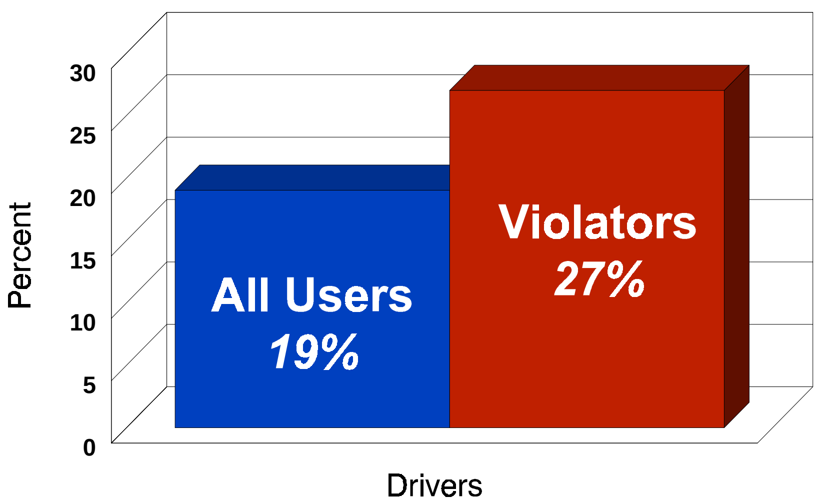


Figure 2 . Percent of Drivers With One Or More Prior Traffic Convictions

Type of Conviction	Percent ofTotal
Failure to Reduce Speed	1.2
Improper Turn	0.2
Unsafe Movement	1.9
Failure to Display License	1.4
Violation Motor Vehicle Law	0.5
Exceeding Safe Speed	2.6
Erratic Lane Change	0.2
Driving Without License	6.7
Failure to Comply With Restriction	0.2
Failure to Yield	0.2
No Liability Insurance	0.7
Ran Red Light	1.7
Failure to Stop at Stop Sign	6.0
Speeding	42.8
No Motorcycle Endorsement	0.2
Driving on Wrong Side of Road	0.5
Reckless	1.2
Illegal Passing	1.2
Revoked License	4.5
Speeding to Elude	0.2
Driving While Intoxicated	6.0
Provisional License Alcohol Violation	0.2
Failure to Appear	16.3
Failure to Pay	3.1

Table 2. Violation Types as a Percentage of Total Violations for Users of Henderson St Grade Crossing (Includes 'Violators')

Convictions for Speeding

In the present case, speeding violations constituted 42.8 percent of all violations. Figure 3 contrasts violators and general users in terms of the percentage of each group having one or more speeding violations. The difference between groups is statistically significant ($X^2 = 3.391$, df = 1, p = 0.066). Speeding, while correlated with an increased likelihood of illegal grade crossing behavior, was not limited to those in the 'violator' group. Seventy-eight percent of drivers in the user group indicated that they had, on occasion deliberately exceeded the posted speed limit. Twenty-three percent indicated that they had on occasion received a citation for speeding. There were no significant differences between violators and the general user group on non-speeding related violations when considered collectively (p = .55).

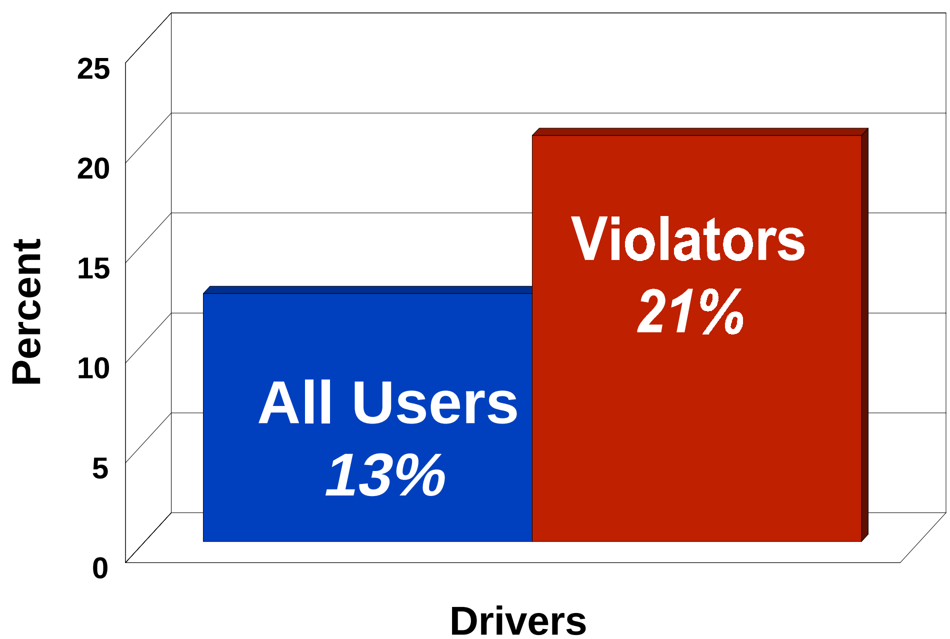


Figure 3. Percent of Drivers With Prior Convictions for Speeding

Total Crashes

Figure 4 contrasts violators and general users in terms of total crashes. While only 75 percent of drivers in the violator group were crash-free, 82 percent of general users were crash-free. While these differences are in the expected direction, they do no reach statistical significance (X^2 = 2.049, df = 1, p = 0.152) at the 0.10 level.

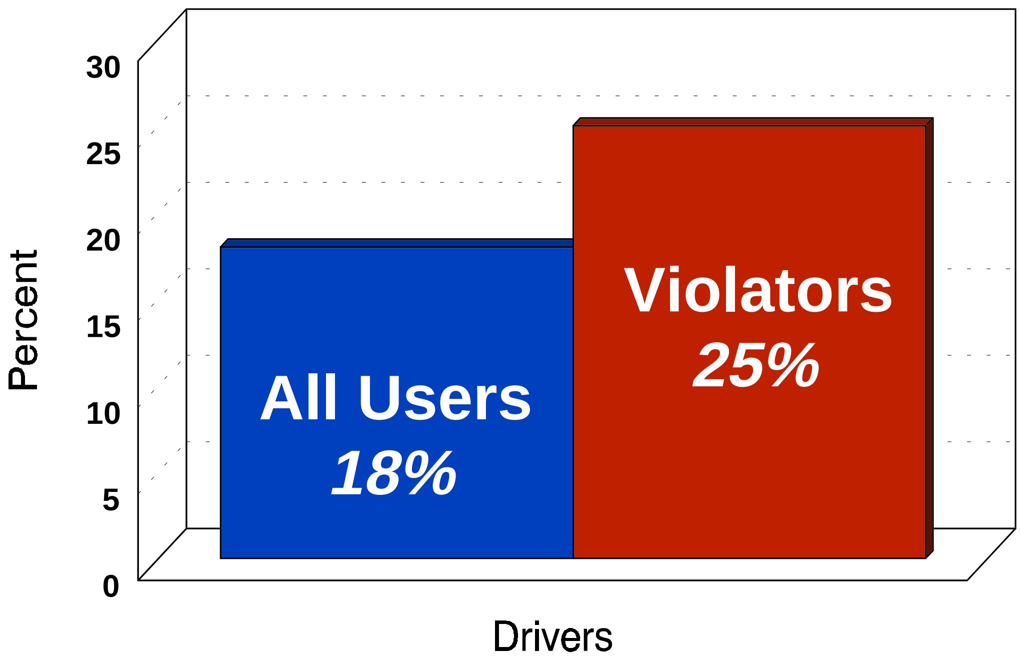


Figure 4. Percent of Drivers With One or More Prior Accidents

Gender of Driver (Male vs Female)

There were no statistically significant differences between general users and violators in terms of the gender of the driver ($X^2 = .110$, df = 1, $p = .740$). In both the general user and violator samples, the ratio of males to females was approximately 3:2.

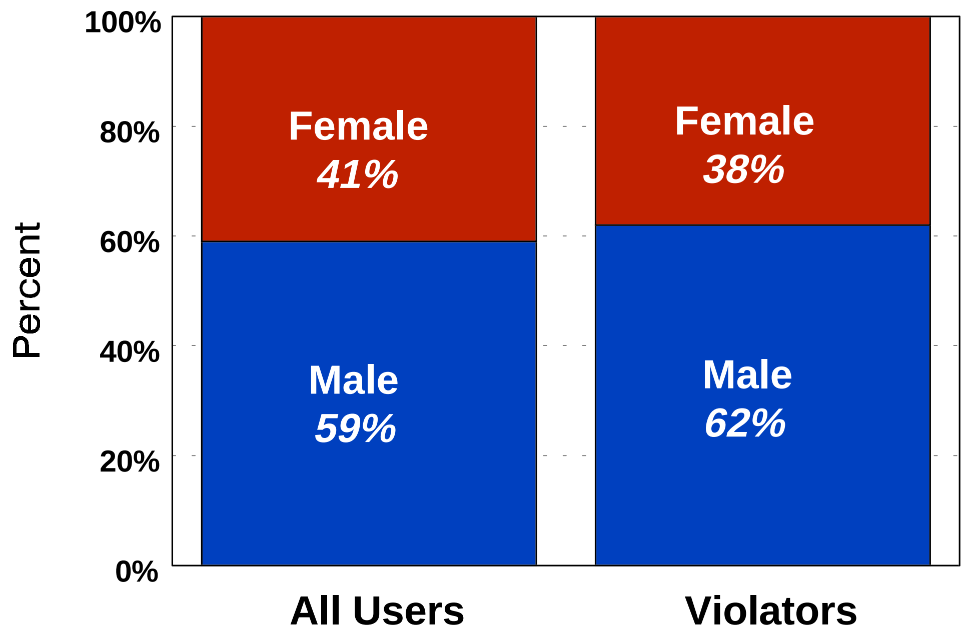


Figure 5 Gender of Drivers in Sample of Violators and Sample of General Grade Crossing Users

Driver Age

There were, however, significant differences between violators and the general class of system users in terms of age (X^2 =9.932, df =3, p =.019). Violators were over represented in the 16 to 30 and 31 to 60 year age ranges and under represented in the 61 to 70 and 71 and over age ranges.

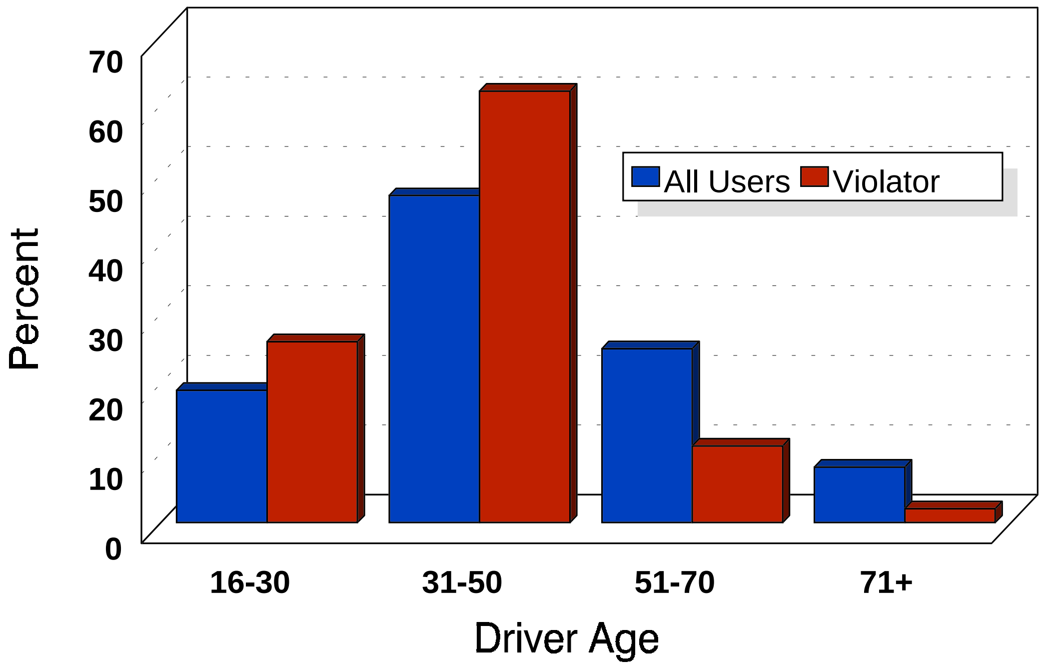


Figure 6 . Age of Driver in General User and Violator Samples

Summary of Driver History Differences

- The male to female ratio of drivers in the ‘violator’ group was no different than that in the at large group of drivers observed to use the Henderson Street grade crossing. In both groups, the male:female ratio was approximately 3:2.

- In terms of driver age, violators were over represented in the 16 to 30 and 31 to 60 year old age ranges; under represented in the 61 to 70 and over 71 year old age categories.

- Drivers identified in the present study as ‘violators’ were statistically more likely to have been convicted of prior speeding violations than drivers in a sample of grade crossing users at large. While there were trends toward grade crossing violators having a greater number of overall convictions for traffic violations and a higher number of crashes, these trends were not statistically significant.

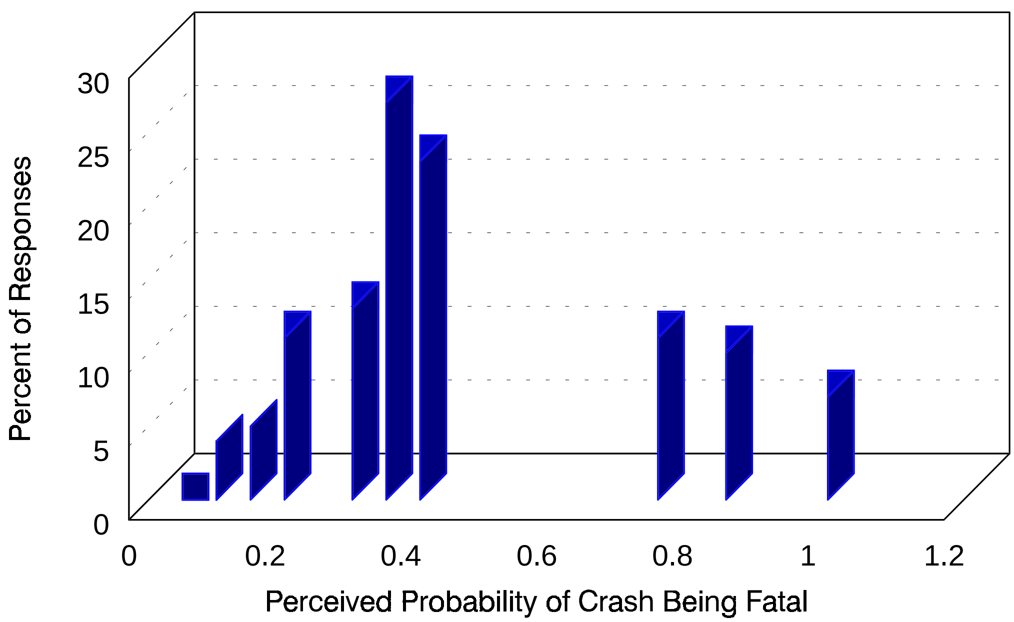
- Since the study’s definitions of prior crash involvement and prior traffic violations were set at ‘zero’ versus ‘one of more,’ caution should be used in drawing inferences from these results, especially where ‘trends’ did not reach the formal 0.10 level of significance established for this exploratory study. Caution should also be exercised in as much as these trends do not take into account the severity of the violation (e.g., DWI, speeding, versus ‘violation of motor vehicle law,’ etc) or ones individual responsibility in the causation of a crash. Clearly, more extensive data are required before driver history information can be used as a reliable indicator of the propensity to engage in illegal actions at railroad grade crossings.

Section II: Responses to Driver Questionnaire

This section summarizes drivers responses to items on a questionnaire developed by HSRC for the present study. The questionnaire is included in the Appendix of the present report.

Perceived Risk of Grade Crossing Incident Being Fatal

Respondents were asked in questions 1 and 2 on the questionnaire to give their estimates of the number of annual grade crossing crashes (in this case for the year 1995) and the number of crashes which they believed were fatal for that year. For these data one can calculate individual driver estimates of the probability of a crash being fatal. The data, summarized in Figure 7 show that drivers in general perceived the likelihood of a crash between a train and a vehicle as somewhat less than 4 chances in 10. Drivers' less-than-chance estimates of how often a grade crossing crash was fatal is surprising given that 86 percent indicated (in Item 6) that they (correctly) perceived the force of a train when striking a car to be equivalent to that of an automobile running over a soda can. In addition, nine out of ten also indicated that they had seen a train strike a car (could have been a dramatization) and were therefore at least familiar with the force of such an impact.



*** Derived from drivers' independent estimates of annual grade crossing crash frequency and number of fatals. . . as opposed to a direct estimate of probability of fatality given a collision with a train.**

Figure 7. Drivers' Perceptions of the Likelihood of Grade Crossing Crashes Being Fatal (see footnote)

The data in Figure 8 suggest the presence of an inverse relationship between drivers' perceptions of the overall number of grade crossing crashes and the likelihood that those crashes are fatal. In other words, drivers who had the lowest estimates of the number of annual grade crossing crash es tended to have the highest estimates that such crashes were fatal.

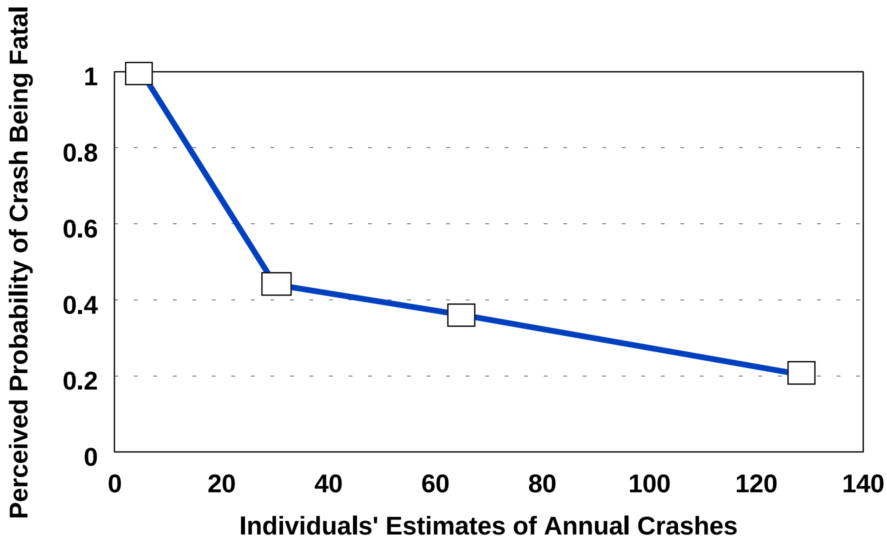


Figure 8. Drivers' Perceived Probability of a Crash Being Fatal Given Their Perception of the Frequency of Annual Grade Crossing Crashes

Drivers' Perceptions of Train Operations

When drivers were asked for their estimates of the time between when the gates go down and when the train actually arrives at the crossing, approximately 1 out of every 4 believed there to be a full 60 seconds (see Figure 9). Twelve percent believed they had anywhere from one to five *minutes* before the train arrived. The modal (most typical) response was 30 seconds. Collectively, the data indicate the presence of a wide range of driver perceptions about this important temporal characteristic of grade crossing operations.

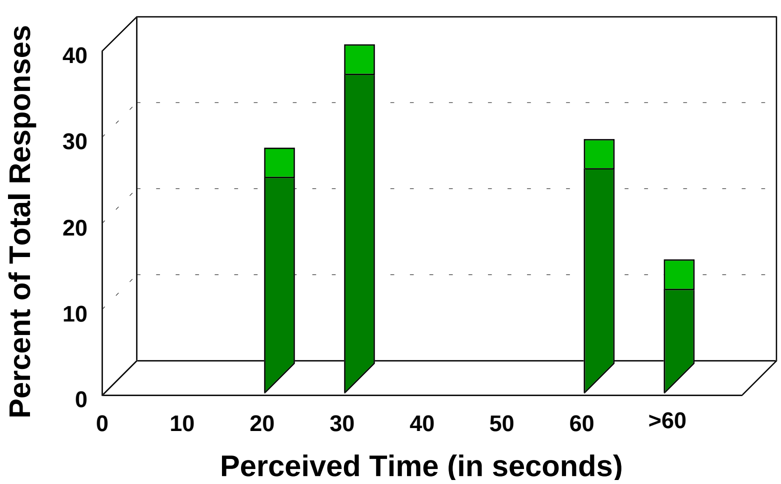


Figure 9. Driver Perceptions of the Time Between Lowering of the Gates and the Time When the Train Arrives at the Crossing

The data in summarized in Figure 10 indicates that 3 out of every 10 drivers who responded to the questionnaire were unaware of the threat posed by the slow moving train (in terms of drivers being likely to underestimate its speed).

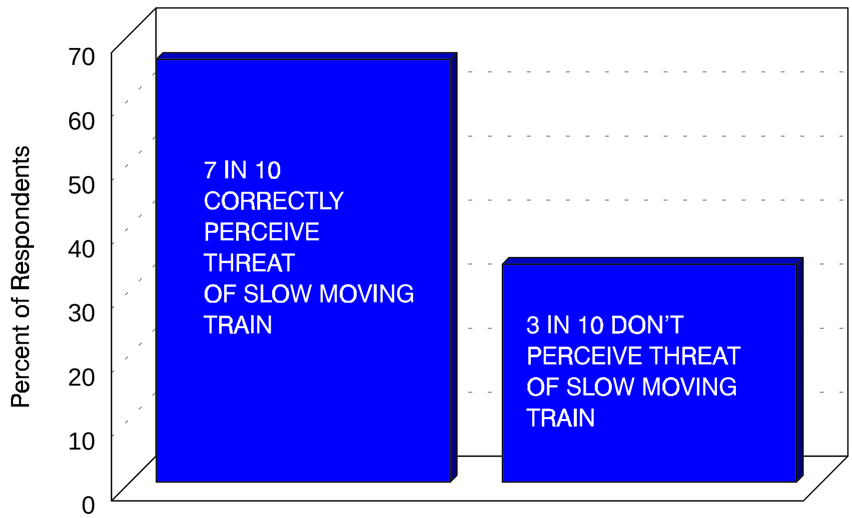


Figure 10. Misperception of Threat Associated With Slow Moving Train

While the vast majority of drivers were correct in their perception that a train traveling at 55 mph could require a mile or more to come to a complete stop, fourteen percent of drivers who responded to the questionnaire believed it was possible for a fully loaded train traveling at 55 miles per hour to come to a complete stop in 300 feet or less; that is, in approximately the same distance required for a fully loaded tractor trailer truck to come to a complete stop on dry pavement (see Figure 11)

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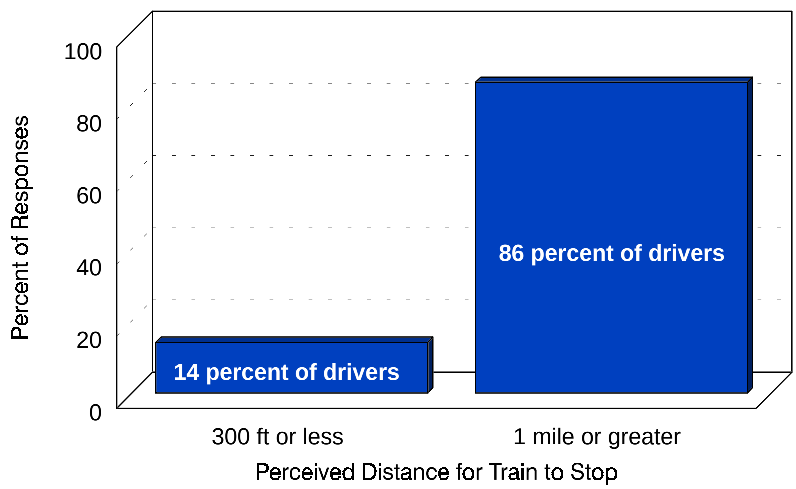


Figure 11. Drivers' Perceptions of the Time Required for a Train to Come to a Complete Stop

While the majority of drivers appear to be knowledgeable about train and grade crossing ‘dynamics,’ the concern lies with the non-negligible percentage of those who do not.

According to Drivers, What Factors Influence Their Behavior at Railroad Grade Crossings

Drivers were asked to rank the importance of various factors associated with their decision as to whether or not to proceed through the grade crossing. Their responses are summarized in Table 3.

To the extent that the driver chooses to ignore the signals (gate lowering and lights flashing) and attempts to cross, the data suggest that his/her estimation of the risk involved in most influenced by the actual sight of the train; next by his/her judgement of the time before the train will arrive at the crossing; and somewhat less by the perceived speed of the train. Past experience at the location and the number of tracks are judged to play less of a role than the physical presence and perceived speed of the train. Despite the fact that the number of tracks is related to the time to cross (a definite factor given the uneven conditions found at the Henderson St crossing) as well as to the likelihood of other trains, number of tracks was rated at the least important factor.

FACTOR	Low (1) to High (10)
Actual Sight of the Train	9.15
Judgement of Time Until Train Reaches Crossing	8.18
Perceived Speed of the Train	8.08
Likelihood of More than One Train	7.91
Past Experience at this Location	7.24
Number of Tracks	6.94

Table 3. Relative Importance of Factors Influencing Driver’s Decision to Cross Once Signal Has Been Activated

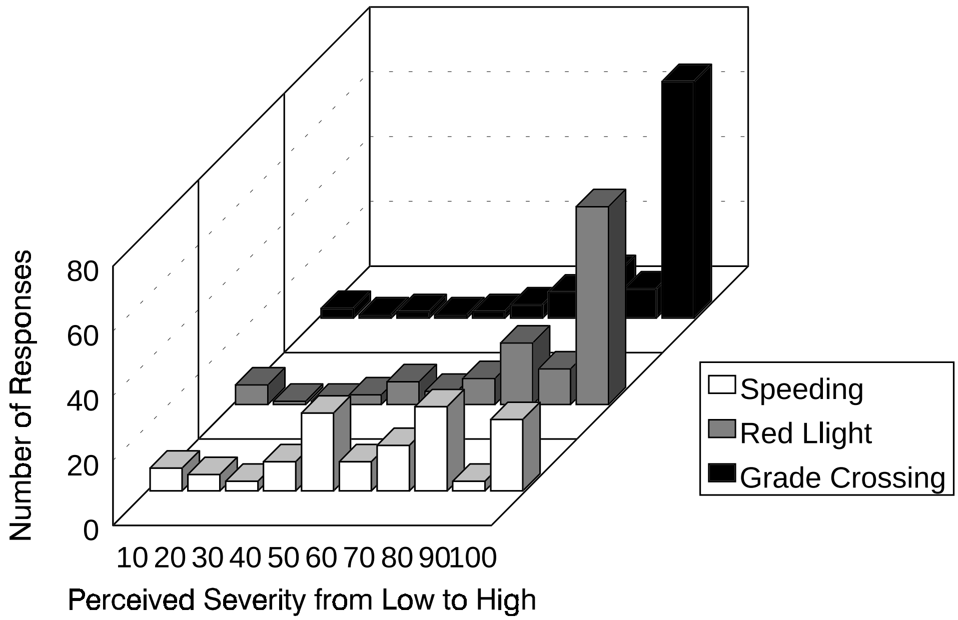


Figure 12. Drivers' Perceptions of the Severity of Speeding, Red Light Running, and Railroad Grade Crossing Violations Relative to That Associated With a Common Parking Ticket.

How Do Drivers Perceived Grade Crossing Violations Compared to Other Traffic Violations?

Figure 12 shows drivers perceptions of the severity of various traffic violations compared to their perceptions of the severity associated with a common parking ticket, where the latter was assumed to be '10' on a scale from 10 to 100. The data shows that running a red light and crossing illegally at a railroad grade crossing were perceived generally to be in the same class in terms of severity with the grade crossing violation being slightly more severe. The severity of speeding is clearly perceived to be less than either a grade crossing violation or a red light violation, with driver ratings of the latter being spread across a much wider portion of the scale.

Perceived Equivalence of Traffic Control Devices at Railroad Grade Crossings and Signalized Intersections.

Drivers were asked to compare their behavior under different signal phases encountered at a railroad grade crossing to their behavior under different signal phases at a signalized intersection (see Table 4) in terms of the extent to which signalization. Their responses suggest that flashing lights in the absence of gate operation or physical sighting of a train would not be sufficient to keep roughly 30 percent of drivers from crossing the tracks. Even when the sight of the train and operation of the gate(s) occur in conjunction with the flashing signals, their responses suggest that roughly 6 percent would still attempt to cross if it were possible. Eight percent indicated that such conditions were, to them, equivalent to the message conveyed by an amber (caution) light at a signalized intersection.

Flashing lights, gate still in 'up' position, train not in sight

62 percent see as equivalent to yellow signal at intersection
2 percent see it as equivalent to a green signal
32 percent say they would attempt to cross under these condition

Flashing lights, gate coming down, train can be seen in the distance

8 percent see as equivalent to yellow signal at intersection
6 percent say they would attempt to cross under these conditions

Table 4 Perceived Traffic Control Equivalence of Grade Crossing and Intersection Signalization

With respect to the self-reported behavior of drivers at traditional signalized intersections*, all* drivers indicated they would *not* run a red light if vehicles were observed to be approaching from either direction (i.e., the equivalent of 'the train is in sight'). In the absence of approaching cross traffic, the data suggest that the behavior of a small percentage (5 percent) of drivers (for the most part, men) will not be well controlled by the red phase. The data also indicated that about 1 in 4 drivers during the cautionary (amber) phase of the signal would attempt to make it through the intersection even if another vehicle were approaching from the right or left. Wherever the system allows the driver to make a judgement, whether it be a railroad grade crossing or a signalized intersection, the data suggest that some percentage of drivers will, on occasion, opt to accept more risk than others under these conditions. It is the 'extremes' of the distribution of road users that is the concern. . . that is, a small percentage of drivers who are likely, some small percentage of the time, to engage in some form of inappropriate system behavior.

Indications of Driver Willingness to Take Risks

A small proportion of drivers (approximately 6% in this case) reported that taking risks can be *'exciting.'* Ten percent of drivers reported that they sometimes take risks even when they know that in doing so they may be injured or even killed in the process. Thirty percent of drivers reported that they may, on occasion, engage in behavior that is 'wrong,' so long as they consider it to affect no one but themselves. Fifteen percent indicated they would go around the gates at a railroad grade crossing if they were sure they would not be caught.

While recognizing the level of danger associated with trying to 'beat the train,' 3 percent of drivers said they would at tempt it. . . if they thought they were *'safe.'* The perception of personal safety must be interpreted in light of the fact that well over 10 percent of drivers who responded to the questionnaire grossly overestimated the time between gate operation and arrival of the train at the crossing; the fact that 30 percent of drivers failed to recognize the danger associated with a slow moving train; and the fact that 14 percent of drivers equated a train's ability to stop with that of a tractor trailer truck under ideal road and weather conditions. Moreover, for about l in 10 drivers, 'safety' considerations seem to apply only to individuals in the car (i.e., not to the passengers and operator of the train).

These data support what may be obvious to many; that is to say, that the behavior of drivers at railroad grade crossings is not completely governed by the traffic control devices installed and operated for their collective safety.

The responses of drivers to items on the questionnaire suggest that for some small portion of the driver population, 'risk,' even though recognized and acknowledged, may not be a sufficient condition to ensure appropriate driver behavior. Not only may some drivers will be willing to 'accept' more risk than others, but some may actually find risk, under some conditions, to be motivating.

In addition to the driver's perception of the risk involved and his/her willingness to proceed in the face of that risk, the data suggest that a variety of 'social' factors are also involved. Twenty-seven percent of drivers indicated they would go around or under the crossing gates if they saw others doing it. One in ten drivers indicated that they personally would not be deterred from illegally going around the gate while others were present. Two percent of drivers said they would even go around waiting vehicles in order to go around gates in the down position.

The presence of a physical gate lowered across the travel lane, the regulatory effect of signs and flashing lights, the individual driver's recognition of the risk(s) involved, and the social control exerted over inappropriate behavior by the presence of other drivers cannot ensure that all drivers will engage in appropriate behavior at railroad grade crossings.

Section III:
Integrating Driver History and Questionnaire Data: Drawing Inferences About The Role of Risk Perception and the Willingness to Engage in High Risk Behaviors

The data reported in Section I pointed to a possible relationship between certain driver history variables (age, recent crash involvement history, and speeding convictions) and the likelihood of engaging in illegal railroad grade crossing activities. In Section II, driver questionnaire data collected from a sample of typical grade crossing 'users' suggested that there is some small proportion of the driver population whose behavior at intersections and railroad grade crossings is not well controlled by existing traffic control measures and regulations, the perceived risk(s) associated with inappropriate or undesirable behavior at these locations, or the social control exerted by the presence of other drivers. The results of the analysis reported in Section III address the possibility of a link between the types of driver history correlates of grade crossing violations identified in Section I and the reported willingness on the part of some drivers to accept, or to even by motivated by, a high level of risk. The major findings are listed below:

- Drivers with prior convictions for speeding were statistically more likely to express the view that taking risks could be 'exciting' compared to drivers with no history of convictions ($X^2 = 5.540$, df =1, p = 0.019).

- Those with prior speeding convictions were also statistically more likely to express the view that trying to 'beat the train' at a railroad grade crossing placed no one at risk other than themselves and the passengers in the car ($X^2 = 7.525$, df = 1, p = .006). The same perception was true for drivers with prior traffic convictions (all types), not just speeding. . . although speeding was the most common of all violations.

- In terms of the perceived level of risk associated with the average person attempting to cross the tracks once the crossing signal had been activated, those convicted of prior traffic violations judged the risk level to be significantly lower than drivers with no prior convictions ($X^2 = 4.029$, df = 1, p =0.045).

- The data suggest that impulsiveness or a lack of patience may be more characteristic of those with prior convictions as indicated by their expressed unwillingness to wait for the green at an intersection where there is no approaching traffic ($X^2 = 2.686$, df = l, p = 0.10). The data suggested that this breakdown in signal control would not be significantly offset by the presence of another car immediately behind the individual in question.

- The data also suggest that those with histories of convictions for prior traffic violations may be less well controlled by signalization than drivers without prior violations. Based upon responses to the questionnaire, those with prior convictions were significantly less likely to equate the flashing red signal at a RR grade crossing with the red phase of the conventional traffic signal (in other words, to associate it more with the message conveyed by either a green or amber signal phase).

- Those with prior speeding convictions reported a significantly higher likelihood of actually attempting to cross under these conditions (in terms of percentages. . . twice as likely than for those with no prior speeding convictions.

SUMMARY

The present data show that a history of speeding and other prior traffic convictions (in this case, over the past four year period) as being correlated with an increased likelihood of convictions for illegal RR grade crossing behavior. The data also show that such driver histories tend to be significantly correlated with a lower perception of the risk associated with attempting to 'beat the train,' a limited perception of the potential risk to those other than the driver (e.g, to those on the train), and a perception of signalization that is more 'advisory' than 'regulatory' in nature. Drivers with convictions for prior violations were also significantly more likely to express the view that taking risks could be 'exciting,' suggesting that the problem of illegal grade crossing behavior is not only one involving judgement of the level of risk involved, but also a situation where risk itself may play a *motivating* role.

Clearly we do not yet understand all the factors which give rise to the driver behavior of voluntarily proceeding around a physical barrier intended to keep motorists out of the path of an approaching train. The present data suggest that whatever variables contribute to driver behaviors that result in traffic violations (in particular, speeding) may also in some way contribute to the likelihood of illegal and dangerous behavior at railroad grade crossings.

We have *'inferred'* by way of a demonstrated (statistical) link between driver history variables and responses to risk-related items on the questionnaire that grade crossing violators may be individuals with an altered sense of the risk(s) associated with such behavior and, in fact, that such individuals may actually find such risky behavior 'exciting.' The reader is reminded that this conclusion is based upon an 'inferred' relationship between risk perception and grade crossing violations inasmuch as actual violators in the present study refused to voluntarily complete the questionnaire.

DISCUSSION

While the results of the present study may provide some sense of increased understanding of the driver who, on occasion, violates the law by ignoring physical and regulatory measures intended to protect drivers from the path of oncoming trains, they provide us with no reliable 'behavioral' or 'social' countermeasure to control its occurrence.

It is highly unlikely that railroad grade crossings will ever be sensitive to the past performance of the driver or the manner in which the driver's assessment of risk influences his or her momentary behavior. To say that inappropriate behavior at a railroad grade crossing is somehow a generalized behavior associated with a certain type of individual does nothing to decrease the likelihood of occurrence of that behavior, and certainly does nothing to effectively 'seal' the high speed corridor.

Similarities Between RR Grade Crossings and Surface Street Intersections

It should not be surprising that the type of signalization and control measures provided at railroad grade crossings are not uniformly effective with all drivers on all occasions. Other than the presence of a gate across the travel lane, the only things serving to stop the motorist are the regulatory impact of the flashing light, the presence or anticipation of the oncoming train, and/or the social control exerted by the presence of other motorists or other passengers in the car. . . events not greatly different from those which control the behavior of motorists at regular surface street intersections.

One suspects that the reason for the gate at the grade crossing versus the surface street intersection derives from the fact that a train, unlike a large commercial vehicle, generally cannot stop in time to avoid a crash, and from the fact that the difference in mass between a train and a passenger vehicle almost guarantees that the consequence of the collision will be severe. Those who pull out in front of trains and those who pull out in front of large commercial vehicles probably have in common a faulty perception of the speed at which the larger vehicle is approaching, a gross overestimate of the time remaining before the larger vehicle reaches their location, and a gross underestimate of the time required for them to 'clear' the intersection/track area. And probably in neither case do the drivers consider the possibility of injury to persons other than themselves.

Reasons for Poor Stimulus/Signal Control

Drivers involved in such crashes, whether it be with a truck or a train, often report that they 'never *saw* the other vehicle'. . . as hard as that may be to believe. What is clear is that they *'behaved'* as is they never saw the other vehicle. There may be some validity to that statement.

An observation of gate and train operations at the Henderson St crossing indicates that there are a number of times when the gates operate, but no train appears. This does not mean that the gates operate spuriously, but rather that all trains which activate the switch mechanism do not eventually proceed through the crossing. This is a situation that is not all that uncommon where crossings are in close proximity to switching operations.

What the motorists 'sees' or 'learns' about the relationship between the sight of the flashing signals and the lowered gate is that these events are only *partially correlated* with the threat of a train. The same can occur where a motorist's experience with a signal or traffic control device at an intersection is more often correlated with the 'absence' of approaching traffic than it is with its presence. This partial correlation is probably, in part, related to some drivers' perception of traffic signals (to include those at railroad grade crossings) as *'advisory'* in nature.

Unlike traffic control devices operating on a fixed cycle length regardless of the presence of approaching vehicles, railroad crossing gates are always associated with the presence of train. . . and usually a train which is visible to the motorist. But what is the motorist learning over time? He is learning that the sight of a train and the operation of the gates is frequently a signal that it is safe to cross. . . a condition which from a learning standpoint is worse than gate operation in the clear absence of a train.

And where the motorist compliantly sits and waits until the yard engine backs off the switch, what the motorist has experienced (and to some extent learned) is that on occasion the interval between gate activation and approaching train can be extremely long. . . which serves to add longer than normal intervals to the 'sample' from which motorists over time 'compute' an expected time of train arrival. It a motorist's perception of the time between gate activation and train arrival is simply the 'mean' of all the intervals experienced in the past, then one can see how drivers come to over estimate the time before the train will reach the crossing.

What we have at an operating location such as the Henderson St crossing in Salisbury is a case where the regular user over time is exposed to conditions where flashing lights and lowered gates are frequently associated (in a learning/conditioning sense) with the absence of a real threat, even though a train may be physically visible in the distance. Over time, the effectiveness of the signalization and traffic control present at the location become ineffective, guaranteeing the eventual occurrence of a collision (the signals and gate are still predictive of an oncoming train, but their effect in controlling the type of motorist behavior that is desired is greatly reduced).

RECOMMENDATIONS

What then can be done to reduce the likelihood of inappropriate driver behavior at railroad grade crossings given (a) the tendency of the system, on occasion, to actually shape inappropriate driver behavior and (b) the potential for 'risk' and its perception or misperception to give rise to inappropriate behavior.

- The only way to *guarantee* the presence of a 'sealed' corridor is to physically prohibit the opportunity for vehicles to be present on the tracks when a train is approaching. There are no known methods for ensuring the level of learning and behavioral/social control necessary to eliminate drivers from engaging in inappropriate behavior either intentionally, or as the result of misperception or poor judgement.

- Signalization and gate operation at railroad grade crossings, in order to exert the level of control over driver behavior required for safety, must be *perfectly correlated* with the conditions about which they are intended to inform drivers. Switching operations which result in unnecessary gate operations, motorists' sightings of trains which do not proceed through the crossing and which result in long intervals where no train ever arrives are all detrimental to motorists acquiring appropriate behavior at grade crossings.

- One should not rule out totally educational and enforcement countermeasures. To the extent that driver perceptions of the risk(s) associated with grade crossing operations can be improved through education and training, such efforts should be undertaken, but monitored carefully for their effectiveness.

- A zero tolerance approach to illegal grade crossing behavior cannot be achieved through traditional, manpower intensive approaches to enforcement. Photo-based enforcement methods combined with a fine/penalty structure that is appropriate to the severity of the violation represent effective alternatives to traditional manpower-intensive methods.

- Where it is not possible or feasible to physically seal grade crossings from vehicles on the tracks, measures that have been shown to reduce the likelihood of undesirable driver behavior (median barriers, gate extensions, quad gates, etc.) should be used. While not eliminating the possibility of train-vehicle collisions, they can serve to reduce the opportunities for such collisions and, in turn, the number of deaths associated with such collisions.

- It goes without saying that the elimination or reduction of unnecessary grade crossings (through closures, overpasses, underpasses, etc) represent effective means for reducing the exposure of motor vehicles to trains.

APPENDIX

NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

RAILROAD GRADE CROSSING

DRIVER SAFETY SURVEY

1998

FACT SHEET
FOR PARTICIPANTS IN NCDOT RAILROAD GRADE CROSSING STUDY

This is a research study.

This research is being conducted for the Railroad Division of the North Carolina Department of Transportation in conjunction with the Norfolk and Southern Railroad. The UNC Highway Safety Research Center is supporting the data collection and analysis portions of the study.

The goal of the research.

The study is concerned with how to provide *increased public safety* at points where roadways must cross high speed rail service, such as those crossings involved in the proposed high speed corridor between Raleigh and Charlotte. The study is especially concerned with the potential need for methods other than the standard gate and signal mechanisms to effectively safeguard motorists and rail users at such crossings.

How you were selected to participate.

The research study is interested in the responses of motorists using the railroad grade crossing at Henderson Street in Salisbury, NC between August 1998 and December 1998. When you return the survey form, we will provide you, compliments of the Norfolk and Southern Railroad, a free pass for travel to points between Charlotte and Rocky Mount, NC. We must received your completed survey

Your participation is voluntary.

The survey which you are being asked to complete and return implies in no way that you are a motorist whose behavior is not effectively governed by these devices. There are occasions, however, when some or all motorists perceive it as being 'safe' to cross when the system indicates otherwise. We want to determine the extent to which ones perception of risk under these conditions is related to (a) general knowledge of crossing operations, (b) understanding of the information provided by the flashing signals and gate, (c) rationale for when it is safe to disregard the information provided by these signals, (d) perception of legal and behavioral consequences for failing to comply with these signals, (e) general level of perceived risk compared to that experienced in other traffic control situations (e.g, failing to stop for a red light or stop sign), and (f) overall driving experience.

Your answers are confidential and will in no way affect your driving record.

The survey should take only a few minutes of your time. Your answers will be used to form a more accurate impression of motorists' behavior at signalized railroad crossings and to improve the safety of the proposed high speed rail corridor between Raleigh and Charlotte. Your honest reply to these questions is essential to the success of the research. Your answers will in no way become a part of the state maintained public record of your driving history, and will under no conditions be reported by name as part of the analysis/results of the study.

If you have further questions.

Questions should be directed in writing to either Mr.Paul Worley, NCDOT Assistant Director for Engineering Safety, Capital Yard, PO Box 25201, Raleigh, NC 27611, or to Mr. Adam Mastrangelo, Research and Test Laboratory, North and Southern Railroad, 110 Franklin Rd, SE, Roanoke, VA 24042-0077.

Your return of the completed survey is an indication of your consent given your understanding of the facts presented above.

Name (Last, First)_____________________ NC Driver's License No. ________________
Date ______________

"DID YOU KNOW?"

1. In North Carolina during 1995, there were how many crashes involving vehicles colliding with trains? (Circle your answer)

   5 30 65 130

2. In North Carolina that same year (1995), approximately how many of these crashes were fatal?

   5 10 25 50

3. From the time the gate goes down at a RR grade crossing, how long is it generally before the train arrives at the crossing?

   20 sec 30 sec 1 min 1-5 min

4 The majority of collisions between trains and cars involve trains traveling at speeds of 35mph or less.

   True False

5. In approximately 1/4 of all train/car collisions, the car runs into the *side* of the train.

   True False

6. A train striking an automobile exerts a force equivalent to an automobile running over a soda can.

   True False

7. A fully loaded train of 100 cars, traveling on level track at a speed of 55 mph requires how far to stop? (Circle you answer)

   a. 200 feet
   b. 230 feet
   c. 300 feet
   d. 1 mile or more

WHAT DOES THE LAW SAY?

8. The train always has the right-of-way, no matter from what direction it is coming.

   True False

9. The Uniform Vehicle Code (UVC), which is the basis for our state vehicle regulations, states that

"No person shall drive any vehicle through, around, or under any crossing gate or barrier that is closed or is being opened or closed."

   True False

HOW DOES IT LOOK TO YOU?

10. Trains generally appear to be farther away than they really are

   True False

11. Trains, because of their size, generally appear to be traveling slower than automobiles

   True False

Name (Last, First)_____________________ NC Driver's License No. ________________
Date ______________

12. Have you ever witnessed a train strike a car or another vehicle?

Yes No

TELL US ABOUT THIS PARTICULAR CROSSING

13. How often have you, or others that you have seen, gone around or under the RR crossing gates at this particular location?

Never | *Almost Never* | *Sometimes* | *Fairly Often* | *Very Often*

14. How frequently do you cross the tracks at this particular location?

a. Once daily
b. Two or more times daily
c. One more than one day each week
d. One or more times monthly
e. On only one occasion

IT'S YOUR DECISION

15. Sometimes I do things that are 'wrong' if I consider the law to be unfair or not to apply to me.

True False

16. I sometimes do things that might be considered 'wrong' if the consequences of doing it doesn't affect anyone but me.

True False

17. I would consider going around the gate at a railroad crossing only if I was sure that I would not be caught.

True False

18. I sometimes take risks when driving even when I know that I could be injured or killed if something went wrong.

Strongly Disagree | *Mildly Disagree* | *Disagree* | *Agree* | *Mildly Agree* | *Strongly Agree*

19. I think taking risks can be exciting.

Strongly Disagree | *Mildly Disagree* | *Disagree* | *Agree* | *Mildly Agree* | *Strongly Agree*

20. People who try to beat the train at RR grade crossings are putting no one at risk other than themselves and the passengers in the vehicle they are driving.

True False

21. I recognize that crossing the tracks once the signal has been activated can be dangerous. I would never attempt it if I thought I was being unsafe.

True False

22. I would never drive around or under a railroad crossing gate if someone else were in the car.

Strongly Disagree | *Disagree* | *Agree* | *Strongly Agree*

23. If other vehicles are crossing when the gates are down, I would be more likely to do the same thing.

True False

Name (Last, First)_____________________ NC Driver's License No. ________________
Date ______________

24. I would never go around other vehicles that are stopped and waiting at a railroad crossing.

True False

25. It never occurred to me that someone might be seriously injured or killed if the train were to strike a vehicle.

True Fals

26. How dangerous is the act of attempting to cross a set of railroad tracks when a train is approaching compared to proceeding through an intersection where cars are approaching from your right or left.. (Circle your answer)

Much More Dangerous

More Dangerous

About the Same

Less Dangerous

Much Less Dangerous

27. On a 1-to-10 scale, how much risk is involved when the *average person* attempts to cross once theRR crossing signal has been activated?

1 2 3 4 5 6 7 8 9 10 11 12
No Risk *High Risk*
(circle one)

28. Traffic signals are *advisories* but not absolute rules.

Absolutely Disagree	*Sometimes Disagree*	*Usually Agree*	*Always Agree*

WHAT WOULD YOU DO?

29. If I came to an intersection and the light was red, and there was no one coming in either direction, I would proceed through the red light (not wait until green).

True False

30. If you were at an intersection that had a traffic signal and the signal was amber as a car approached from either your right or left, how often would you try to make

Never *Rarely* *Sometimes* *Almost Always* *Always*

(Circle your answer)

31. If you came to an intersection where the light had just turned red, how long would you wait before proceeding through the intersection (assuming no traffic was coming)?

a. 10-seconds
b. 30-seconds
c. 1-minute
d. 2-minutes
e. Until the light turned green

32. If you came to the same intersection and the light was red, and the only car present was one that had just pulled up behind you, how long would you wait before proceeding through the intersection?

a. 10-seconds
b. 30-seconds
c. 1-minute
d. 2-minutes
e. Until the light turned green

Name (Last, First)______________________ NC Driver's License No. ________________
Date _______________

33. Which exerts more legal control over your actions?

a. A railroad crossing signal
b. The traffic signal at an intersection
c. No difference

34. If knew for sure that I could be positively identified when crossing the railroad tracks illegally, the effect on me would be

a. To never cross against the signal
b. To cross against the signal only when I knew I could justify it if caught.
c. To cross only if everyone else was doing it.
d. To cross only if I knew for sure that the signal was malfunctioning
e. To cross only if I knew from past experience that I could make it before t the train arrived.

35. Under no conditions would I ever park in a spot marked 'For Disabled Only."

True False

36. I have never deliberately exceeded the posted speed limit.

True False

37. I have never deliberately run a red light.

True False

38. Did you have any accidents during your first year of licensed driving?

Yes No

39. . . . during your first three (3) years?

Yes No

40. . . .during your first five (5) years?

Yes No

41. I have never received a speeding ticket.

True False

42. I have never received a ticket for running a red light.

True False

43. For which of the following have you received a ticket?

a. Driving too fast
b. Driving while under the influence
c. Running a red light
d. Driving with revoked license
e. Reckless driving
f. Being at fault in an accident
g. Racing

44. On a scale from 1-to-100, if the seriousness of a parking violation was a '10,' what would be the seriousness of each of the following?

a. Exceeding the speed limit

10 20 30 40 50 60 70 80 90 100

b. Running a red light

10 20 30 40 50 60 70 80 90 100

c. Disregarding the automatic signal at a railroad grade crossing

10 20 30 40 50 60 70 80 90 100

Name (Last, First)_____________________ NC Driver's License No. ________________
Date ______________

WHAT GET'S YOUR ATTENTION

Think in terms of the message you get from the usual red-amber-green traffic signal at an intersection. If you now think of a railroad grade crossing as being like an intersection, which would each of the following conditions correspond to if they were 'signaled' in terms of red, amber, and green signals? AND, how likely would you be to cross under each of these conditions?

45. CONDITION: Flashing red lights, gate beginning to lower, approaching train can be seen in the distance.

Is MOST LIKE: (circle one)

Red traffic signal

Amber traffic signal

Green traffic signal

How likely would you be to cross the tracks under these contitions?

Never *Almost Never* *Sometimes* *Almost Always* *Always*

46. CONDITION: Flashing red lights, gate still in 'up' position, train not yet in sight.

Is MOST LIKE: (circle one)

Red traffic signal

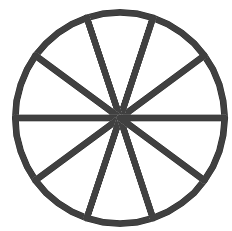
Amber traffic signal

Green traffic signal

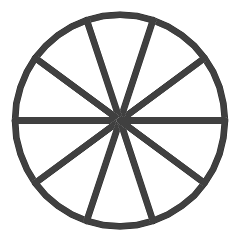
How likely would you be to cross the tracks under these conditions?

Never *Almost Never* *Sometimes* *Almost Always* *Always*

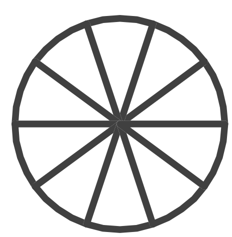
47. You arrive at a railroad grade crossing. The signal is indicating the approach of a train. At that point in time, how much are you influenced by each of the following. Fill in the parts of the circle in proportion to how much you think you are influenced by that particular factor.



Speed of the train

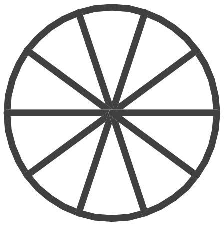


Actual sight of the train

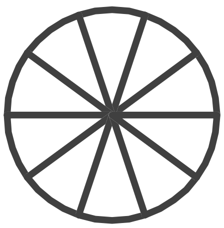


Number of Tracks

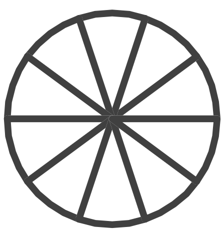
Name (Last, First)______________________ NC Driver's License No. _________________
Date _______________



My Judgement of the Time Remaining



Past experience at this location



Likelihood of more than one train coming from the same or different direction