Standard Title Page -- Report on State Project

1279

Report No.	Report Date	No. Pages	Type Report:	Project No. :
VTRC 90-R9	January 1990	129	Final	9623-069-940
			Period Covered:	Contract No.:

Title and Subtitle
Optimal Speed Limits for School Buses on Virginia Highways: A Report to Virginia's Superintendent of Public Instruction

Key Words
Differential
School Buses
Speed Limit
Speed Variance

Author(s) Jack D. Jernigan and Cheryl W. Lynn

Performing Organization Name and Address

Virginia Transportation Research Council
Box 3817, University Station
Charlottesville, Virginia 22903-0817

Sponsoring Agencies' Names and Addresses

Va. Dept. of Transportation
1221 E. Broad Street
Richmond, Virginia 23219

University of Virginia
Charlottesville
Virginia 22903

Supplementary Notes

Abstract

On Virginia's rural interstate highways there is a three-tiered speed limit: 45 mph for school buses, 55 mph for trucks, and 65 mph for other vehicles. On the urban interstate highways, school buses are restricted to 45 mph, but other traffic has a 55 mph speed limit. Speed theory suggests that (1) restricting school buses to slower speeds will not increase the potential severity of accidents that occur but that (2) slower speeds may function to increase the probability that a school bus will become involved in a crash with a faster-moving vehicle on the interstate highway system.

The study found that 41 states allow school buses to travel at least 55 mph on the interstate highway system, and 22 states allow school buses to travel 65 mph on the rural interstate highways. Surveys of school administrators, school bus drivers, and police agencies and other special interest groups indicated a majority opinion in favor of raising the speed limits for school buses from 45 mph to 55 mph on the rural interstate highway system but retaining the 45 mph maximum limit on the urban interstate highways and on other systems. A major reason cited for wanting an increase on the rural interstate highways was a fear that school buses are in danger of being struck from behind by faster-moving vehicles, especially heavy trucks. A detailed analysis of four years of Virginia accident data (including the one year of exposure to the 65 mph rural interstate speed limit for most traffic) indicated that only 17 crashes occurred during those years, resulting in only six injuries and no fatalities. These crashes were not attributable to the difference in speed limits or to collisions between heavy trucks and school buses. The accident data, therefore, did not support the reasons given by those surveyed for why a higher speed limit would be preferred. Further, because Virginia's school buses are equipped with a speed governor that limits the maximum speed of the bus, a higher speed limit would require raising the speed allowed by the governor. Therefore, this action might function to increase travel speeds not only on interstate highways but on other roads as well, which could have a deleterious effect on school bus safety on the primary and secondary systems. Thus, the study concluded that there are no compelling reasons for Virginia to raise the maximum speed limits for school buses from 45 mph and that there are reasons that caution against raising the speed limit.

OPTIMAL SPEED LIMITS FOR SCHOOL BUSES ON VIRGINIA HIGHWAYS:

A Report to Virginia's Superintendent of Public Instruction

Jack D. Jernigan
Research Scientist

and

Cheryl W. Lynn
Research Scientist

Prepared in Cooperation With the Pupil Transportation Advisory Committee of the Virginia Department of Education and the Joint Secretarial Task Force on Interstate Highway Speed Limits

Virginia Transportation Research Council
(A Cooperative Organization Sponsored Jointly by the Virginia Department of Transportation and the University of Virginia)

Charlottesville, Virginia

January 1990
VTRC 90-R9

TABLE OF CONTENTS

EXECUTIVE SUMMARY

On July 1, 1988, the maximum speed limit for passenger vehicles on Virginia's rural interstate highway system was raised to 65 mph. One year later, the speed limit for commercial, non-school buses was also raised to 65 mph. The speed limits for trucks and school buses on rural interstate highways remained unchanged, however--resulting in a three-tiered speed limit for Virginia's rural interstate highways: 45 mph for school buses, 55 mph for trucks, and 65 mph for other vehicles.

These changes generated some concern within the pupil transportation community that the new speed limit for passenger vehicles and commercial buses might place school buses at increased risk for accidents. Theory and traffic engineering research suggest that (1) the absolute speed at which a vehicle travels is directly related to the severity of an accident involving the vehicle, and (2) the variance and distribution of the speeds of vehicles traveling on a given roadway are related to the likelihood of an accident occurring. For instance, if all vehicles on a highway travel at the same speed and in the same direction, they cannot interact. On the other hand, if they travel at widely different speeds, numerous lane-change and passing interactions occur, which can result in accidents. Since the maximum speed limit for school buses is now 20 mph lower than the maximum speed limit for passenger vehicles and 10 mph lower than that for heavy trucks on rural interstate highways, interactions among these classes of vehicles can often occur. As a result, accident probability theoretically increases.

Officials of the Virginia Department of Education felt that this potential problem needed investigation and requested that the Virginia Transportation Research Council conduct the study documented herein. In addition, because the 45 mph maximum speed limit for school buses is lower than the 55 mph maximum speed limit for other vehicles on urban interstate highways, and often lower than the maximum speed limit for other vehicles on the other road systems, the study team investigated whether changes were needed in the maximum speed limit for school buses on all road systems. However, the primary focus of the study was the question of whether there is a need to change the maximum speed limit for school buses on interstate highways, particularly rural interstate highways.

Purpose and Approach

Although there are many possible criteria by which to assess changes in speed limits--such as convenience, economic benefits and costs associated with the resulting time savings, and public opinion--the overriding consideration in the approach to this study was that the optimal level of safety for students traveling in school buses be

ensured. Thus, this was the primary criterion used to assess whether school bus speed limits should be changed.

Since the safety record of school buses on interstate highways is extraordinarily good, the study team adopted a conservative approach to investigating the speed limit question. Thus, it would be necessary for the study to show that there were compelling reasons for change before any such recommendation would be made.

Findings

Of the 50 states, only 4 others have established school bus speed limits as low as or lower than Virginia's, with only South Carolina having a lower maximum speed limit for school buses. Twenty-two states allow school buses to travel 65 mph on rural interstate highways, and 18 allow them to travel a maximum of 55 mph. Although Virginia is in the minority with regard to the interstate highway speed limit for school buses, this was not considered a compelling reason to change it. In altering or retaining their school bus speed limit on rural interstate highways, there is no evidence that other states did so based on objective, safety-related data. Thus, the fact that there are differences in school bus speed limits does not mean in and of itself that Virginia or other states should change their maximum school bus speed limits. In addition, since school bus travel rarely involves trips between states, uniformity of school bus speed limits is not a necessity for promoting safety or enforcement.

Based on a detailed analysis of school bus accidents, the study team concluded that Virginia does not appear to have a substantial crash problem involving school buses on either urban or rural interstate highways. Only 17 school bus accidents occurred on Virginia's interstate highways in the last four years, and these crashes caused only seven injuries. In addition, it does not appear, based on crash configuration data from one year of experience with the 65 mph speed limit, that increasing the difference in maximum speed limits for passenger vehicles and school buses to 20 mph and retaining the difference in maximum speed limits for trucks and school buses at 10 mph had a deleterious effect on school bus safety. Most interstate highway school bus accidents in Virginia occurred at speeds considerably lower than the maximum allowable, with many occurring on or near entrance and exit ramps. This indicates that the ability of a bus to accelerate or decelerate may be related to crash involvement. It was concluded, then, that (1) the school bus safety problem with regard to Virginia's interstate highways is minimal, and (2) increasing the speed at which school buses may travel, and thus decreasing the passenger vehicle/truck/school bus speed limit differential, is unlikely to improve the already exemplary safety record of school buses traveling interstate highways. Likewise, the accident data did not indicate that there is a substantial school bus crash problem related to the speed limit differential on the other road systems.

Surveys of pupil transportation administrators, school bus drivers, and police agencies and other special interest groups were conducted to determine how changes in the current speed limit for school buses would be received by those working in this area. A majority of those surveyed in all groups supported increasing the school bus speed limit to 55 mph on rural interstate highways. In general, those surveyed did not feel that school buses could operate safely on interstate highways at speeds greater than 55 mph, and they did not support lowering the speed limit for school buses on interstate highways. Further, the majority of those surveyed in all groups did not support changing the maximum speed limit for school buses on urban interstate highways or the other road systems.

Although increasing the school bus speed limit to 55 mph on rural interstate highways would be received favorably by those directly involved, this finding was not considered to be compelling enough to indicate a need for change. That is, although the study team considered the fact that many of the individuals surveyed feared that other vehicles, especially large trucks, would strike the rear of school buses, these fears were not borne out in the accident data since there were so few collisions in the last four years and there were no collisions between large trucks and school buses.

Finally, a survey of the actual speeds that school buses travel on Virginia's interstate highways revealed that Virginia's public school buses conformed closely to the 45 mph maximum speed limit. It was hypothesized that the speed governor on school buses was a major factor in ensuring this close compliance. If the maximum speed limit for school buses on interstate highways is raised, however, the speed at which a governor is set will also have to be raised. School buses would then be capable of traveling at higher speeds, although illegally, on other road systems. Thus, the ability of a speed governor to help ensure compliance with the lower speed limits for school buses on other roadways would be reduced, and this could have adverse implications for highway safety. This was considered to be a compelling reason not to change the current maximum school bus speed limit of 45 mph.

Discussion

A number of options were considered, and several were eliminated. For instance, raising the maximum speed limit for school buses to 60 mph or 65 mph on rural interstate highways was not considered feasible since these limits would permit school buses to travel faster than large trucks and would likely result in increased accident severity. Lowering the maximum speed limit for school buses on any road system was not considered feasible since this change would likely increase passenger

vehicle/truck/school bus interactions and thus the number of crashes without reducing the already-low accident severity level.

Raising the maximum speed limit for school buses on rural and urban interstate highways to 50 mph or 55 mph was considered a viable option. Foremost, a higher speed limit would theoretically reduce the speed limit differential between school buses and other traffic. If the travel speed of school buses was increased, thereby reducing the difference between school bus speed and the average speed of other traffic, the risk of a school bus becoming involved in a crash with a faster-moving vehicle would be reduced. However, if a school bus were to become involved in a traffic crash, the higher travel speed might function to increase the severity of the crash and the probability that school bus occupants would receive serious or fatal injuries. Thus, there are good reasons for and against raising the speed limit for school buses on interstate highways.

Retaining the 45 mph maximum speed limit for school buses was also considered a viable option. When the speed limit for most traffic on rural interstate highways was increased, the probability of a slow-moving school bus becoming involved in a crash may also have increased as a result. However, the slower speed that school buses might travel under a 45 mph speed limit may function to minimize the severity of accidents that do occur.

Conclusions and Recommendations

Although 45 mph, 50 mph, and 55 mph are all viable options for maximum speed limits for school buses on Virginia's interstate highways, none of these options can eliminate the risks associated with transporting students. An underlying assumption in research is that unless there is compelling evidence to indicate that a change is needed, the status quo should be maintained. Although the theoretical accident probability should have increased when the speed limit for most other vehicles was raised on rural interstate highways, accident data from Virginia's one year of experience with the increased differential do not indicate that this increased probability was manifested. Thus, because there were only a few, relatively minor, school bus crashes on the interstate highways under the current maximum school bus speed limit of 45 mph, and because there was not sufficient evidence to support the hypothesis that school bus accident probability increased when the 65 mph rural interstate highway speed limit for most vehicles was implemented, the study team concluded that there was not enough compelling evidence to warrant a change in current speed limit policies pertaining to school buses in Virginia. In addition, one positive aspect of retaining the 45 mph interstate speed limit for school buses involves the effectiveness of a speed governor. Retaining the 45 mph speed limit on interstate highways precludes raising the limit on a speed governor, thereby preserving the efficacy of the device in contributing to speed limit compliance on other roads.

ACKNOWLEDGMENTS

The authors express their gratitude to all of those individuals whose advice and assistance contributed to the completion of this report. Particularly, the authors thank the members of the Pupil Transportation Advisory Committee and the Joint Secretarial Task Force on Interstate Highway Speed Limits for helping define and focus the direction of the study. Also, the authors gratefully acknowledge the assistance of Fred Small, who accessed and provided the accident data from other states and whose comments were valuable in refining the study; the staff of the Department of Education, who collected and coded the accident data for Virginia's school buses; Myron Martin, Jane Mold, Kim Morris, and Emily Vermillion, who toiled over the seemingly endless data entry tasks; Patricia Brady, who conducted the survey of other states' laws and regulations; Lewis Woodson, who traveled across the Commonwealth to conduct the survey of school bus speeds on Virginia's interstate highways; Ravi Kalaputapu, who prepared the sample risk assessment table; Sharon Clark, who prepared the manuscript; the members of the Research Council who reviewed and provided comments on the manuscript; and Linda Evans, whose editorial comments were invaluable in finalizing the document.

The authors also acknowledge the special efforts of two individuals whose contributions were guiding forces behind this study. The authors thank R. A. "Buster" Bynum for his assistance in this study and for his commitment to providing for the safe transportation of students in Virginia. The authors also express their appreciation to Wayne Ferguson, whose contributions to this study are too numerous to mention.

Finally, the authors thank the local pupil transportation administrators and the school bus drivers--not only for completing the surveys they received for this study, but also for their daily dedication to the safety of Virginia's school children.

OPTIMAL SPEED LIMITS FOR SCHOOL BUSES ON VIRGINIA HIGHWAYS:

A Report to Virginia's Superintendent of Public Instruction

Jack D. Jernigan
Research Scientist

and

Cheryl W. Lynn
Research Scientist

INTRODUCTION

On July 1, 1988, the maximum speed limit for passenger vehicles on Virginia's rural interstate highways was raised from 55 mph to 65 mph. Much debate and extensive investigation surrounded the questions of whether to allow vehicles to travel legally at higher speeds and whether particular classes of vehicles should be included among those affected by an increase. However, little attention was focused on what effect a change would have on school bus safety and travel. In fact, raising the maximum speed limit in Virginia resulted in a three-tiered speed limit on its rural interstate highways: 45 mph for school buses, 55 mph for trucks and other buses, and 65 mph for other vehicles.*

A less cumbersome, two-tiered speed limit is in effect for urban interstate highways: 45 mph for school buses and 55 mph for other vehicles. Furthermore, on any highway other than an interstate, the maximum speed limit for school buses is 35 mph or the posted minimum speed, whichever is greater; however, if a school bus does not pick up or discharge passengers between its points of origin and destination, it may travel at a maximum speed of 45 mph (Va. Code 46.2-871).

As a result of Virginia's speed limit policies, school buses are usually limited to traveling at least 10 mph below the speed limit set for most other vehicles and may in some instances be restricted to a speed limit 20 mph below that for other vehicles. The Virginia Department of Education (DOE) became concerned about the possibility that the slower speeds required of school buses might compromise the safety of students. The DOE was also concerned, however, that an increase in the speed limit for school buses might itself compromise the safety of students. Thus, in an attempt to avoid taking steps that might have an

---

*On July 1, 1989, the maximum speed limit for commercial, non-school buses was raised to 65 mph.

adverse impact on school bus safety, the DOE entered into an agreement with the Virginia Transportation Research Council (VTRC) to conduct a study on optimal speed limits for school buses on Virginia's highways. (A copy of the agreement appears in Appendix A.) The VTRC had served as the staff for the Joint Secretarial Task Force on Interstate Highway Speed Limits, which evaluated the potential impact of raising the speed limit on rural interstate highways in Virginia. Like the current study, the estimates of the potential impact of the higher speed limit on interstate highways involved a sensitive public policy issue that needed to be investigated with the utmost care and objectivity.

PURPOSE AND SCOPE

The study of optimal speed limits for school buses was begun in November 1988 and was conducted with the oversight of both the DOE's Pupil Transportation Advisory Committee and the Joint Secretarial Task Force on Interstate Highway Speed Limits. The purpose of this study was to examine the safety characteristics of the current multitiered speed limits and how these characteristics related to the operation of school buses. The VTRC was asked to investigate the advantages and disadvantages of the various speed limit options for school buses, but ensuring the optimal level of safety for school bus travel was the ultimate objective of the study. Economic costs and benefits accrued through time savings are often considered in studies of this nature, but these factors were considered to be inappropriate and of little consequence when compared to the safety of students during travel to and from school and school activities. Thus, with safety as its guiding principle, this study was undertaken in an attempt to provide decision makers with a valid and comprehensive synthesis of the available data so that informed policy decisions could be made on whether to alter the speed limit policies that affect Virginia's school buses or to leave them unchanged. In addition, the study attempted to provide administrators with information concerning optimal routing policies for school buses on interstate and parallel primary highways.

METHODOLOGY

Paradoxically, one of the problems that confronts any investigation of the safety of school bus travel is that travel in these vehicles is safer than in any other vehicle type on the nation's highways (Transportation Research Board [TRB], 1989). Fatal crashes that involve school buses are rare events, and in-bus fatalities and injuries are even

less common. This means that school bus crash data are limited and that there is limited room for improvement in safety. Much of any investigation must therefore focus on identifying theoretical risk factors and determining patterns in the limited data that may help increase safe practices and minimize risks. Given this cautionary note, the remainder of this section of the report outlines the major issues of the study and explains how each was examined.

Laws and Policies of the 50 States

An initial step in assessing Virginia's multitiered speed limit system was to determine if other states had established lower speed limits for school buses than for other vehicles. The staff of the VTRC conducted research on the statutes regarding speed limits for school buses in the 50 states. Seventeen states regulate speed limits for school buses by statute, but many others have provisions that allow restrictions on speed limits for school buses to be established by administrative regulation intiated by the agency responsible for overseeing student transportation in the state.

Because state regulations are not always accessible through library research and are not always well-indexed, it was decided that the best way to obtain comprehensive information about administrative rules was to survey the various agencies responsible for overseeing student transportation. Thus, in December 1988, R. A. Bynum, Associate Director of Pupil Transportation Service for Virginia, sent a survey to the directors of pupil transportation in the other 49 states and provided the VTRC with the requested information for Virginia. (A copy of the survey form appears in Appendix B.)

Speed and Speed Variance

There is a consensus in the literature that stopping distances and crash severity are directly related to increases in travel speeds. Crash probability, however, is generally considered to be related to speed variance and the distribution of travel speeds on a given roadway. In the discussion of speed and speed variance, this report provides an analysis of the literature on crash probability and crash severity and describes how these issues relate to the question of establishing speed limit differentials. The history of Virginia's use of speed limit differentials to regulate the various classes of vehicles, including school buses, is also discussed. Finally, the report provides an analysis of the advantages and disadvantages of establishing speed limit differentials for school buses.

School Bus Speed Survey

In an attempt to measure the level of compliance by school buses with the 45 mph maximum speed limit, the VTRC conducted a speed survey of school buses traveling on interstate highways during morning and afternoon hours in the spring of 1989--hours when school buses would likely be transporting students to and from school or to special activities such as sporting events. In order to avoid potential bias, the VTRC did not inform the DOE, the local school divisions, or the members of the Pupil Transportation Advisory Committee that such a survey was being conducted. A vehicle equipped with a properly calibrated speedometer followed school buses that were traveling on interstate highways in the various regions of the Commonwealth. The sections of interstate highways to be surveyed were chosen subsequent to conversations with Virginia Department of State Police division commanders, who identified general areas where school buses traveled on interstate highways in their division's jurisdiction. The survey vehicle, which was positioned near the on ramp to the interstate highway, paced the school bus after both the bus and the survey vehicle were up to speed. While the school bus was paced, characteristics of the bus--such as its size, whether it was loaded, and its school division--were noted. The speed traveled by the bus was measured numerous times between on and off ramps, and the average of these measurements was used to estimate the travel speed of the bus. An analysis is provided of the travel speeds and the relative speeds of Virginia's public school buses, Virginia's private school buses, and a few school buses from other states that were traveling on Virginia's interstate highways.

Accident Experience

Because school buses have the safest travel record of any class of vehicle on the nation's highways, crash data on school buses are relatively scarce. Although this is a most desirable situation in terms of safety, it means that determining patterns of crashes from the data is difficult, if not impossible.

A recent report on school bus safety (TRB, 1989) was released in the spring of 1989. This study included an extensive analysis of fatal crashes in which school buses were involved in the years 1982 through 1986. The TRB study also provided a detailed description of each fatal crash in which there was an in-bus fatality during those years. (The detailed in-bus crash descriptions are included in Appendix C.) These data were used in this report to analyze how the travel speeds of school buses may have been related to the crashes or their severity.

Likewise, the DOE provided the VTRC with data on all crashes in Virginia involving school buses for the academic years of 1985-86 through 1987-88. These data were also examined to determine whether travel speeds of school buses were related to the crashes or their severity. In addition, detailed descriptions of the limited number of school bus

crashes occurring on Virginia's interstate highway system during this time period were developed and are shown in Appendix D. These descriptions were analyzed to determine if there were common characteristics among these crashes. Finally, accident data were solicited from several other states in an attempt to determine whether uniform or multitiered speed limits affect school bus safety.

Opinion Surveys

When considering any change in policy, whether through legislation or administrative regulation, it is crucial to anticipate the reaction of all involved parties prior to implementing the change. Anything less than an enthusiatic response from groups directly involved, such as school bus drivers and pupil transportation administrators, could adversely affect the implementation of a change. In addition, opposition by public and private special interest groups could result in unfavorable publicity and affect compliance with the change.

For these reasons, three groups (pupil transportation administrators, school bus drivers, and police agencies and other special interest groups), which would be affected by a change in school bus speed limits, were surveyed. Each of the groups was asked several questions in common and then a number of questions specific to their own interests and expertise. (Copies of the three questionnaires appear in Appendix E.)

Because the number of identified special interest groups and pupil transportation administrators was relatively small, all members of these two groups were surveyed (see Table 1). There are, however, 13,138 active public school bus drivers in Virginia. For this reason, a sample of 1,195 drivers was chosen to be polled, with 487 participating in the survey. This sample size ensured that, with 95 percent confidence, the results of the survey would come within 10 percent of the results that would have been obtained by polling all drivers. (For more information on sample size calculations and sampling assumptions, see Appendix F.)

TABLE 1

Response Rates for School Bus Speed Limit Opinion Surveys

Survey Group	Total Population in Virginia	Number of Surveys Sent	Number Returned (%)	% Representation
Pupil Transp. Administrators	129	129	127 (98.4)	98.4
School Bus Drivers	13,138	1,195	487 (40.8)	3.7
Special Interest Groups	205	205	81 (39.5)	39.5

Risk Assessment Modeling

At the outset of this study, it was agreed that a risk assessment model would be provided for local pupil transportation directors to use in deciding whether to route school buses onto interstate highways or implement other alternatives. Because school bus crashes on interstate highways are relatively rare events, school bus crash data alone would not provide enough information to assess adequately the risks associated with these decisions.

The study team decided to use proxy measures to determine the relative levels of risks for interstate highways and parallel primary routes. Accident rates for all vehicles and for trucks only were calculated for interstate highway segments and for parallel primary routes. The segments that have lower crash rates for other vehicles would be considered to be associated with less risk for school bus travel. In particular, the study team was interested in truck crash rates because trucks share some characteristics with school buses, which are generally built on a truck chasis, that they do not share with passenger vehicles.

ANALYSIS

The first step in the analysis of the data was to review the statutes and regulations governing school bus speed limits in the 50 states. Once the statutory review was complete, the commonly accepted theory relating speed characteristics and accidents was related to what could be expected for each alternative for school bus speed limits. Actual speeds traveled by school buses on interstate highways were then examined to determine whether school buses currently comply with Virginia's policy. Once this background information was reviewed, actual accident experiences involving school buses were analyzed. Finally, the results of the opinion surveys were analyzed. These data were then integrated to determine if there was compelling evidence to indicate that a change in current school bus speed limits was needed.

Laws and Policies of the 50 States

Table 2 displays the maximum speed limits for school buses in the 50 states. It also indicates whether the maximum speed limit for school buses is lower than that for other vehicles. A brief description of any special provisions or exemptions for school buses and the applicable code or regulation sections are also noted. The reader should be cautioned, however, that these maximum speed limits often apply to interstate or

TABLE 2

Speed Limits For School Buses
(By Statute and/or Administrative Regulations)

State	Maximum Speed for School Buses	Lower Than Limits for Other Traffic?	Special Provisions, Exceptions for School Buses	Applicable Code/Statute/Reg.
Alabama	65	No		
Alaska	65	No		
Arizona	65	No		
Arkansas	65	No, but for large trucks is 10 mph less than max. permissible		
California	55	Yes, 65 mph for cars; 55 for trucks and towed vehicles	Applies only when transporting any student	VC 22406
Colorado	65	No	Speed should be governed by "reasonable judgment"	CCR 301-26 4204-R 211-00
Connecticut	50	Yes, 55 for others	50 mph on divided limited access highways	14-281a
Delaware	65	No		
Florida	55	Yes, 65 for others		316.183 Bd. of Ed Rule: 6A-3.017(1)2.p
Georgia	55	Yes, 65 for others	55 on interstate, all trips; 55 on other roads if no pickups/discharges; 40 on other roads, all trips	40-6-160 DOE Regs.: sect. ED
Hawaii	55	No		
Idaho	55	Yes, 65 for others		IDAPA 08.02.G 4,4,r

continues

TABLE 2 (Cont.)

State	Maximum Speed for School Buses	Lower Than Limits for Other Traffic?	Special Provisions, Exceptions for School Buses	Applicable Code/Statute/Reg.
Illinois	65	No, but large trucks and towed vehicles: 55 mph	65 on divided hwys.; 55 on others	95 1/2-11-1 601
Indiana	55	Yes, 65 for most others; 45 for oversized vehicles	55 on federal/state; 40 on county/township roads	20-9.1-5-10
Iowa	65	No	Different speed limits for school buses abolished in 1983	
Kansas	55	Yes, 65 for others	55 for all trips, all roads, except 45 for dirt/sand/gravel	8-1558
Kentucky	55	Yes, 65 for others		Admin Reg., Title 702, ch. 5, 29
Louisiana	65	No	Each parish (county) has authority to set speed limits within its jurisdiction	R.S. 32:64
Maine	55	Yes, 65 for others	55 on "other trips"; 45 to/from school	29 1252
Maryland	45	Yes, 55 for others	Applies only while carrying passengers	21-806
Massachusetts	55	No	55 on limited access hwys.; 40 on others	90-17
Michigan	50	Yes, 65 for others		257.627
Minnesota	65	No		
Mississippi	50	Yes, 65 for others	50 on "other trips"; 45 to/from school	37-41-47

continues

TABLE 2 (Cont.)

State	Maximum Speed for School Buses	Lower Than Limits for Other Traffic?	Special Provisions, Exceptions for School Buses	Applicable Code/Statute/Reg.
Missouri	65	No	An advisory committee has recommended 55 max. limit	
Montana	65	No		
Nebraska	65	No	On non-hard surfaces: 45 daytime, 40 night	Regs., ch. 29 008.01
Nevada	65	No		
New Hampshire	65	No		
New Jersey	55	No		
New Mexico	55	Yes, 65 for others		Bd. of Ed. Reg. 83-3.1.4
New York	55	No		
North Carolina	45	Yes, 65 for others	35 to/from school; 45 if no pickups/ discharges; 45 if fewer than 16 passengers; 55 for "special activity buses"	20-218
North Dakota	65	No	55 on blacktop, other than interstates; 45 on gravel roads	Regs. of Supt. of Public Instruction
Ohio	55	Yes, 65 for cars and commercial buses, 55 for school buses and vehicles over 8,000 lb		4511.21
Oklahoma	65	No	50 mph on all roads other than interstate	47 11-801

continues

TABLE 2 (Cont.)

State	Maximum Speed for School Buses	Lower Than Limits for Other Traffic?	Special Provisions, Exceptions for School Buses	Applicable Code/Statute/Reg.
Oregon	55	Yes, 65 for others		811-115(1)(b)(c)
Pennsylvania	55	No	Local districts may restrict buses	
Rhode Island	45	Yes, 55 for others	45 on limited access; 35 on all others	Regs. for School Buses 4.5
South Carolina	35	Yes, 65 for others	There is an exception (45 mph) for buses used to transport handicapped (longer distances)	59-67-525 Trans. Reg. #14
South Dakota	65	No		
Tennessee	55	Yes, 65 for others	55 on federal/state hwys.; 35 on county roads	49-6-2110
Texas	50	Yes, 65 for others		Motor Vehicle Act 6701d, 166
Utah	65	No		
Vermont	55	No		
Virginia	45	Yes, 65 for cars, 55 for trucks	45 on interstates; 35 on non-interstates; 45 if no pickups or discharges	COV 46.2-871 Bd. of Ed. Regs. 2.2
Washington	60*	Yes, 65 for most traffic; 60 for all vehicles over 10,000 lb	School buses not specifically mentioned in statute	46.61.410
West Virginia	65	No	School buses must follow truck speed limits where posted	Bd. of Ed. Regs. 4336

continues

TABLE 2 (Cont.)

State	Maximum Speed for School Buses	Lower Than Limits for Other Traffic?	Special Provisions, Exceptions for School Buses	Applicable Code/Statute/Reg.
Wisconsin	65	No		
Wyoming	65	No		

SUMMARY:

(1) 65 mph: 22 states
60 mph: 1
55 mph: 18
50 mph: 4
45 mph: 4
35 mph: 1

(2) 22 set lower speed limits:
17 by statute,
9 by regulation
(some have both)

(3) 28 states treat school buses as any other motor vehicle.
Of those with restrictions,
12 states further restrict speed limits by nature of road.
5 states further restrict speed limits by nature of trip.
Only Virginia and Indiana appear to have a 3-tiered speed limit on rural interstates.

rural interstate highways only. Restrictions may apply to other roadways.

Twenty-two of the 40 states that have a maximum speed limit of 65 mph on rural interstate highways also allow school buses to travel at 65 mph. Interestingly, 2 of these states (Arkansas and Illinois) also restrict large truck traffic to 55 mph. One state (Washington), which has a 65 mph speed limit on its rural interstate highways, restricts its school buses and all other traffic with a gross vehicle weight of 10,000 pounds or more to 60 mph.

Eighteen states allow school buses to travel a maximum of 55 mph. Twelve states restrict school buses to 55 mph, whereas most other traffic is allowed to travel 65 mph on rural interstate highways. The other 6 of these states do not have a lower speed limit for school buses but have a 55 mph maximum speed limit for all vehicles.

Four states have a 50 mph maximum speed limit for school buses, which is lower than for other traffic. In Connecticut, the maximum speed

limit for other vehicles is 55 mph, but the maximum speed limit in the other 3 states is 65 mph.

Virginia is among 4 states (also Maryland, North Carolina, and Rhode Island) that restrict school buses to a 45 mph maximum speed limit. Maryland and Rhode Island have a 55 mph maximum speed limit for other vehicles, but Virginia and North Carolina have a 65 mph speed limit on rural interstate highways for most other vehicles.

Finally, South Carolina restricts its school buses to a maximum speed limit of 35 mph, which eliminates school bus travel on interstate highways because 35 mph is below the minimum speed limit for these highways. An exception is made in South Carolina for school buses that transport handicapped students, and these buses are allowed to travel 45 mph. The reason given for this exception is that handicapped students normally need to be transported longer distances than other students.

As can be seen in Table 2, various other types of restrictions may apply to school bus travel. Some restrictions are based on the type of trip, others on the type of roadway, and others on both. When the classification is based on the type of trip (e.g., "no pickups or discharges" or "to and from special activities"), an enforcement problem may arise. Under current Virginia law, it is possible for two school buses to travel the same non-interstate road at the same time but to be subject to different speed limits: 45 mph if there are no pickups or discharges and 35 mph if there are. This law may be virtually impossible to enforce because there is almost no way for an officer to know what type of trip the bus is making unless he or she witnesses a stop where students are either loaded onto or discharged from the bus.

In summary, 22 states allow school buses to travel 65 mph on rural interstate highways, and 1 state allows them to travel 60 mph. Eighteen states have established a 55 mph maximum speed limit for school buses, and this represents a speed limit differential in 12 of these states. The remaining 9 states have a speed limit differential for school buses. Four allow school buses to travel 50 mph, four 45 mph, and one 35 mph. In all, 28 states treat school buses as any other type of vehicle and 22 have special provisions that establish a speed limit differential for school buses. Only Virginia and Indiana appear to have a three-tiered speed limit on rural interstate highways. Virginia restricts trucks to 55 mph and school buses and special permit vehicles to 45 mph. Indiana limits school buses to 55 mph and oversized vehicles to 45 mph. Virginia is among the 5 states with maximum speed limits for school buses that are 45 mph or less. Further, Virginia and North Carolina are the only states that limit school bus speeds to 20 mph below that for most other traffic on rural interstate highways. North Carolina, however, has a provision to allow both yellow and non-yellow activity buses to travel 55 mph. Further, North Carolina requires non-activity school buses to flash a

high-mounted yellow light while traveling on interstate highways in order to increase the visibility of the slow-moving school bus.

Speed and Speed Variance

Many of the arguments that were made for and against differential speed limits for trucks may also apply to school buses. There are special considerations concerning school buses, however. Handling characteristics and occupant protection standards are very different for school buses, thus affecting their crash and injury-producing potential. These vehicles also carry students whose life has been entrusted to the schools. Another limitation of the comparison is that the speed limit differential for school buses is sometimes 20 mph, not 10 mph as is the case for trucks. In spite of these differences, the truck differential analogy is useful in considering the school bus speed differential.

In the 1950s and 1960s, the use of differential speed limits was widespread in the United States, especially along the East Coast. At one time, more than half of the eastern states had a differential speed limit for trucks. Virginia also has a history of establishing a differential maximum speed limit for passenger vehicles and larger and heavier vehicles. Beginning in 1938, Virginia's first truck differential limit was imposed, with the speed limit for passenger vehicles set at 55 mph, for trucks at 45 mph, and for school buses at 35 mph (see Table 3).

TABLE 3

Virginia's Maximum Speed Limits: 1930 to the Present

Year	Passenger Vehicle Speed Limit	Truck Speed Limit	School Buses
1930-1938	45	45	35
1938-1942	55	45	35
1942-1946	35	35	35
1946-1948	50	50	35
1948-1952	55	50	35
1952-1960	55	45	35
1962-1964	65	50	35
1964-1968	65	50	45
1968-1972	65	55	45
1972-1977[a,b]	70	60	45
1977-1988	55	55	45
1988-Present	65	55	45

[a]On November 26, 1973, the maximum speed limit for all vehicles was lowered to 55 mph by a proclamation issued by then Governor Holton. The law itself, however, was not changed until 1977 (Section 46.193).

[b]In 1974, the definition of truck changed from vehicles exceeding 5,000 pounds to vehicles exceeding 7,500 pounds.

Most of the arguments put forth concerning differential speed limits are based on "common sense." Most are based on a recognition of the obvious differences in the operating and handling characteristics of trucks and other larger and heavier vehicles (such as school buses) and smaller passenger vehicles. Because of the greater weight of trucks, school buses, and other large vehicles, the severity of crashes involving these vehicles tends to be greater than that of crashes involving passenger vehicles only. Large vehicles also have a slower rate of acceleration and deceleration than do smaller vehicles, and they take longer to get up to speed and to stop than do passenger vehicles. In addition, the higher the speed, the greater the difference between passenger vehicles and large vehicles in terms of stopping distance, which makes consideration of this factor important when raising speed limits.

Although there are strong arguments in favor of establishing a speed limit differential, differences in the characteristics of passenger vehicles and large vehicles may counter these arguments. For instance, in trucks and school buses, the driver is in a position relative to the road that is higher than that in passenger vehicles. Thus, the driver's sight distance is increased, thereby giving him or her more reaction time when encountering an obstacle. This may partially counteract the potential deleterious effects of increased stopping distances.

On the other hand, speed limit differentials may put slower-moving vehicles at risk for being struck from behind by faster-moving traffic. If a passenger vehicle strikes a larger vehicle from the rear, the occupants of the larger vehicle are generally not placed as much at risk as the occupants of the passenger vehicle. The mass of the larger vehicle may function to protect the occupants of the larger vehicle whereas it results in more damage and more severe injuries to the occupants of the passenger vehicle. However, school buses require special consideration because unlike trucks they often carry passengers in the rear. Further, if a large truck collides with the rear of a school bus, the mass and momentum of the truck would place the occupants of a school bus at great risk for injury or death.

Thus, from an intuitive point of view, there are rational arguments for and against speed differentials. However, these arguments neither conclusively establish the need for a differential nor anticipate the impact of a differential on traffic safety once imposed. In order to determine the impact of establishing different speed limits, a review of the literature on the relationship between accidents and differential speed limits was conducted.

Relationship Between Accidents and Differential Speed Limits

The rationale upon which the use of a speed differential is often based is the assumption that if the speed for a class of vehicle is

lowered, such vehicles are less likely to be involved in motor vehicle accidents, thereby resulting in improved traffic safety. The assumption made is that the class of vehicle assigned the lower speed limit is associated with a lower level of safety when traveling at the speed assigned to other traffic. It remains to be determined whether this assumption is valid.

Although this theory suggests that differential speed limits reduce accident probability, both previous research and accident experience have shown that this assumption is not valid. The speed that a vehicle travels is not correlated with the likelihood that it will be involved in an accident, but rather speed is related to the severity of the consequences of accidents that occur. As the speed a vehicle travels increases, the severity of any crash involving the vehicle will increase, especially at speeds in excess of 60 mph (Solomon, 1968). This makes intuitive sense, since the higher the speed traveled, the higher the energy that must be absorbed by the occupants and the vehicle in a collision. In fact, a 20 percent increase in speed from 50 mph to 60 mph results in a 44 percent increase in the kinetic energy that must be absorbed, thus dramatically increasing the severity of the consequences of an accident (Kelley, 1973). The relationship between kinetic energy and speed is given by the equation:

$$\text{Kinetic energy} = 1/2 \text{ Mass} \times \text{Velocity}^2.$$

Thus, any increase in the change in velocity brought about by an impact increases kinetic energy proportionately to the square of the velocity, which disproportionately increases the severity of the accident outcome. The relationship between kinetic energy and velocity for a fully loaded school bus (30,000 lb) is shown in Figure 1. It can be noted that even a small increase in speed results in a disporportionate increase in impact forces.

An example of this principle is often given by the National Highway Traffic Safety Administration (NHTSA) when releasing the results of crash tests conducted on new cars. The NHTSA notes in its press releases that a 35 mph crash into a solid barrier is one third more severe than a 30 mph crash into such a barrier.

Related to the issue of crash severity is the question of the crashworthiness of school buses at high speeds. Few crash tests have been performed on these vehicles, and all have been conducted at speeds of 35 mph or less. Even a 35 mph impact with a solid barrier is considered an extremely severe crash with the potential for serious injury or death. Thus, even with a 35 mph change in velocity at impact, there is a high probability that school bus passengers would be at risk for serious injury or death, and at higher changes in velocity at impact, the risk would increase. Thus, it is clear that the severity of a crash

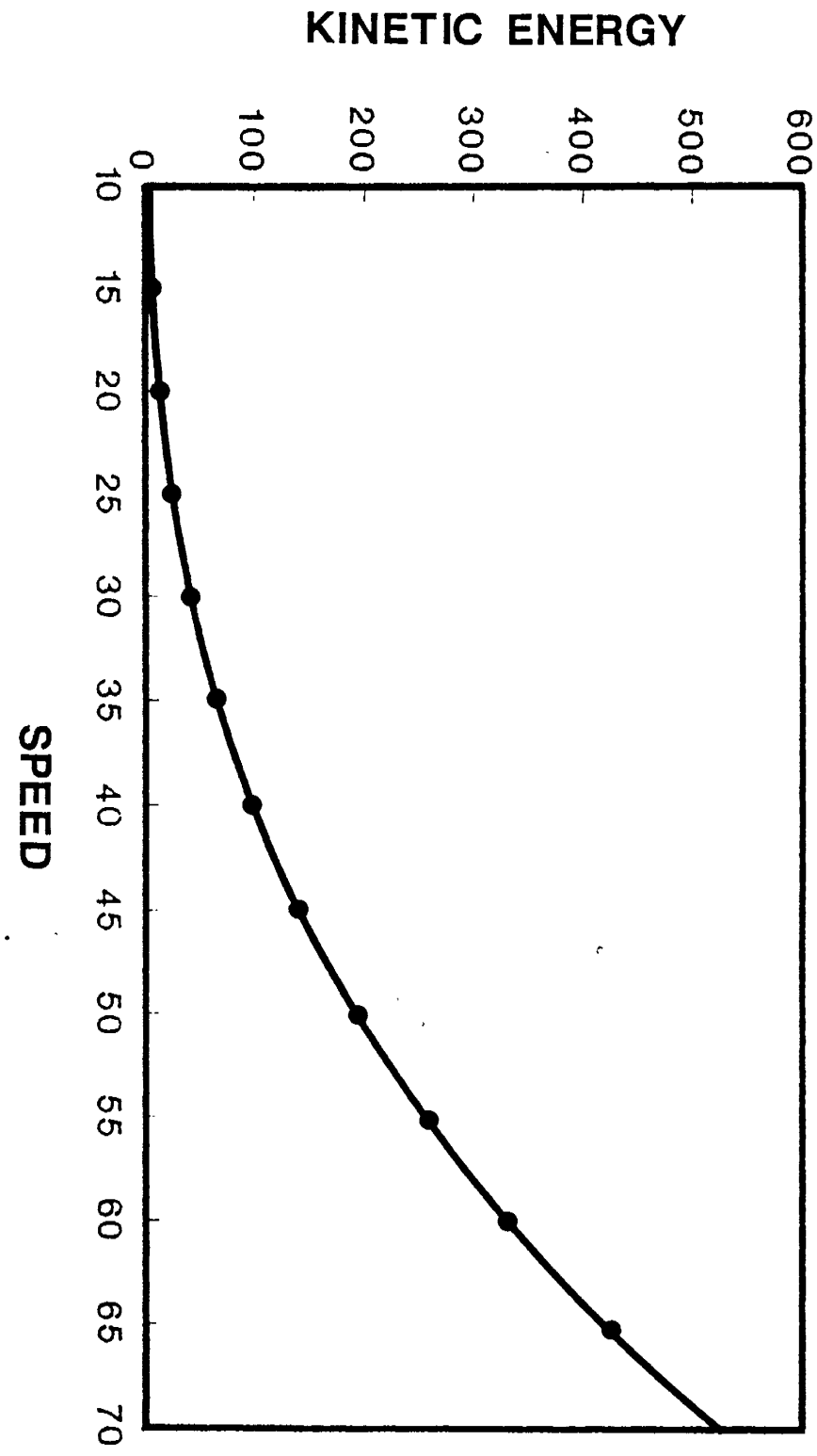


Figure 1: Kinetic Energy Curve for a Fully Loaded School Bus

is increased at higher impact speeds; however, no clear-cut relationship has been established between absolute travel speed and crash probability.

One factor that does seem to affect the probability of a crash occurring is the speed of the vehicle in relation to the speed of all other vehicles on the road at the time. The greater the discrepancy between a vehicle's speed and the average speed of other vehicles on the same section of road, the more likely the vehicle is to be involved in an accident (Solomon, 1968; Johnson, Klein, Levy, & Maxwell, 1976; Michaels & Schneider, 1976; Research Triangle Institute, 1976; Garber & Gadirau, 1988). This also makes intuitive sense since vehicles traveling the same speed and in the same direction do not interact with each other because they never overtake one another. When vehicles travel at widely varying speeds, however, the number of interactions, such as overtaking and passing, is maximized (Hauer, 1971). It has also been noted that the closer a vehicle travels to the average speed, the fewer the interactions; therefore, the opportunities for a crash to occur are minimized. Thus, accident involvement rates have been shown to vary directly with speed variance; that is, how a vehicle's speed differs from the average speed. Also, it has been shown that the fatality rate tends to be highest at speeds that are either much higher or much lower than the average speed (Solomon, 1968). This relationship between variation from the mean speed and the probability of an accident is illustrated in Figure 2. It is clear from the figure that accident involvement rates are lowest when a vehicle's speed approaches the mean or the 85th percentile speed (the speed at or below which 85 percent of vehicles travel). Further, speeds substantially lower than the mean speed tend to be associated with more of a risk for crash involvement than speeds that are substantially higher than the mean.

These speed characteristics are important to remember when considering the potential effects of a speed limit differential, which tends to increase speed variation. On interstate highways, increasing speed variation would theoretically serve to increase the number of rear-end and lane-change interactions between school buses and other traffic, theoretically increasing the potential for these types of accidents.

A special consideration of the speed limit differential in Virginia relates not to travel speed on interstate highways, but rather to travel speed on primary and secondary systems. Virginia's public school buses currently have a governor that mechanically limits the maximum speed of a bus to 45 mph. If the maximum speed limit were increased, the governor would have to be adjusted to allow a bus to travel at the higher speed. A governor set at a higher speed would not only permit the operation of the vehicle at that speed on interstate highways but would also give drivers the option of traveling faster on other roadways. Obviously this practice would be illegal, but an advantage of the current system is that a working governor now limits school bus speeds to 45 mph.

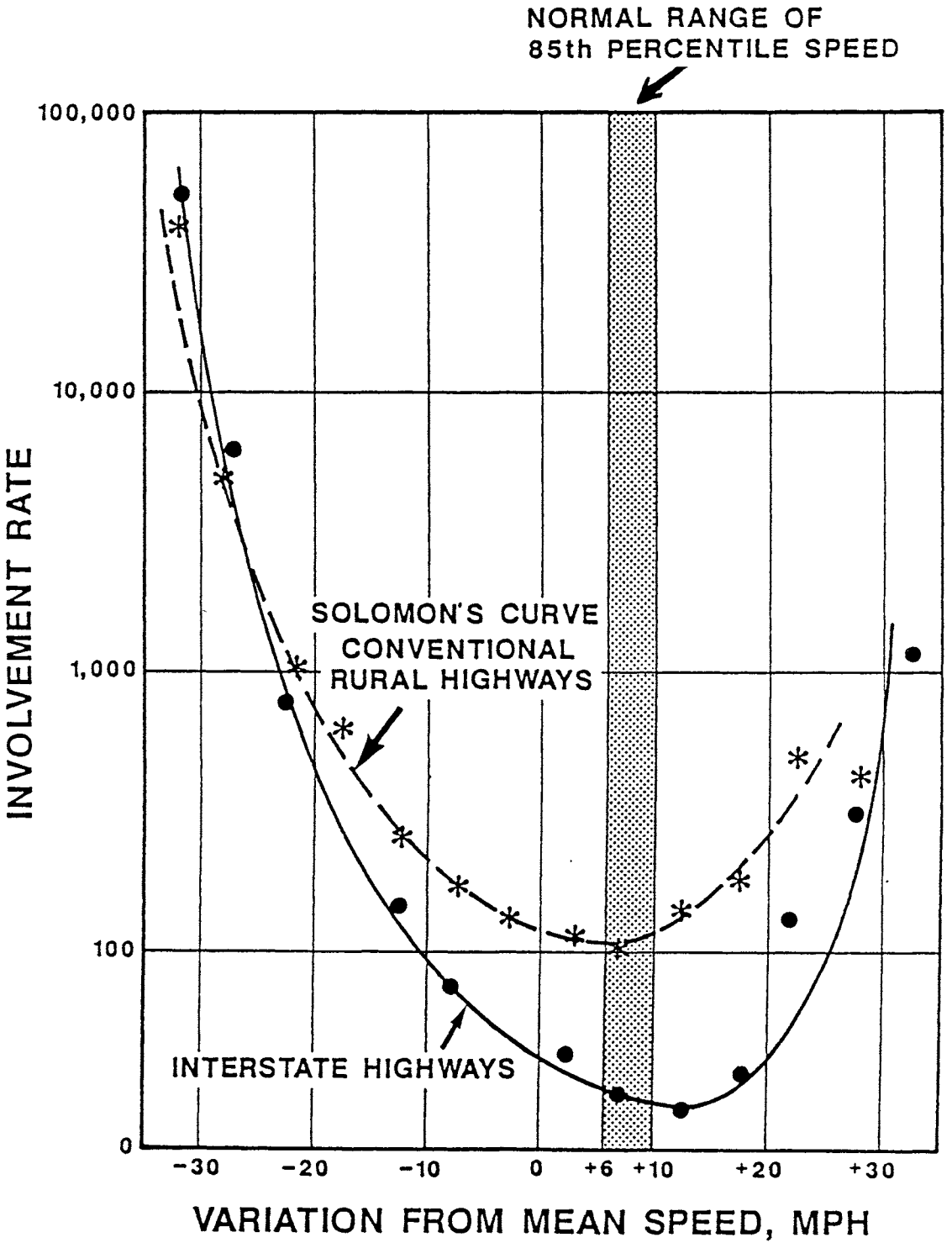


Figure 2: Accident Involvement vs. Variation From Mean Speed (Solomon, 1968)

School Bus Travel Time and Exposure to Accidents

Another reason for establishing higher speed limits for school buses involves decreasing the amount of time that a school bus would take to reach its destination. The convenience of reduction in travel time should not be considered; however, a reduction in travel time may function to reduce school buses' exposure to traffic and therefore reduce exposure to crash situations. In other words, the faster a bus reaches its destination, the faster it can be removed from potentially dangerous traffic situations. Reduced travel time might also reduce the potential for driver fatigue. Because there is no evidence in the literature to support or refute these arguments, it is the opinion of the study team that the benefits provided by a reduction in travel time should be considered, at best, cautiously.

Summary of Speed and Speed Variance

There are several reasons for and against establishing maximum speed limits for school buses that are lower than those for other vehicles. Lowering the travel speed of school buses would theoretically reduce the severity of a crash. Further, a speed limit differential helps compensate for the handling limitations of school buses, such as steering and braking capacity, and allows for more maneuverability and decreased stopping distances. The differential, however, serves to increase the difference between the speeds of school buses and other vehicles, thus increasing the variance between the speeds of the classes of vehicles, the interactions between vehicles, and the theoretical probability of accidents occurring.

School Bus Speed Survey

In order to determine how fast school buses travel on Virginia's interstate highways, school buses were observed in the spring of 1989. This survey revealed interesting contrasts. Table 4 shows that although the number of observations was small, the speeds observed for Virginia's public school buses were substantially lower than those for Virginia's private school buses and those for school buses from other states that were traveling in Virginia.

Virginia's public school buses were traveling at an average speed of 48 mph, with most of the observations clustered near the mean. The minimum speed measured was 43 mph and the maximum 58 mph. Nine of the 42 Virginia public school buses observed, however, were traveling in excess of 50 mph. Since 20 percent of the school buses were traveling in excess of 50 mph, it is clear that at least some speed governors are not working as intended.

TABLE 4

Survey of Travel Speeds for School Buses
on Virginia's Interstate Highways

School Bus Type	No. Observations	Average Speed
Kentucky	1	64
Maryland	1	55
North Carolina	1	55
Virginia Private	3	55
Virginia Public	42	48

The three Virginia private school buses that were observed were all paced at 55 mph, as were the buses from North Carolina and Maryland. A school bus from Kentucky, however, was paced at 64 mph on a rural portion of Virginia's interstate highways that had a 55 mph speed limit for all buses clearly posted. In fact, in Kentucky, the maximum speed limit for school buses is 55 mph, so the Kentucky bus was also clearly in violation of the limit established in its home state. Although the Maryland school bus was traveling in excess of Virginia's maximum speed limit for school buses, 55 mph is the speed that Maryland allows its school buses to travel. Likewise, although the North Carolina school bus was a yellow bus, it was clearly marked as an activity bus. North Carolina allows such buses to travel as fast as 55 mph. These buses must be specially marked and used only for activity trips, not for regular morning and afternoon student transportation.

Based on these data, the study team concluded that there is both substantial compliance with the speed limit and consistency in the speeds traveled by school buses on Virginia's interstate highways. Also, based on the average speeds of passenger vehicles and trucks on interstate highways (63 mph and 58 mph, respectively), there is a difference in the actual speeds traveled. This difference is higher than that imposed under the previous legislation mandating a 55 mph speed limit for both passenger vehicles and trucks. In theory, the increased differential should result in increased accident probability for school buses.

Another conclusion that can be drawn from these data is that appropriately geared school buses without a governor or with a governor set higher than Virginia's are now can travel at least 55 mph on interstate highways. It is hypothesized that a governor functioned, at least in part, to increase compliance with Virginia's 45 mph maximum

speed limit for school buses. If speed limits are raised on the interstate highways, the maximum speed allowed by a governor will also have to be raised, thus allowing buses to travel, albeit illegally, at higher speeds on all roadways.

Accident Experience

In the final analysis, the question this study sought to answer was: Would the conditions under which school buses are currently operating on Virginia's roadways be made safer by changing the current speed limit provisions? There is evidence that accidents that occur at higher speeds are more likely to result in more frequent and more severe injuries than accidents occurring at lower speeds. This fact would argue against raising the speed limit for school buses on interstate highways. On the other hand, a higher speed limit that would at least equal that for trucks and would more closely approximate that for passenger vehicles would reduce the wide variation in speeds actually traveled, thereby reducing interactions between vehicles and the probability of accidents occurring. All of this information, however, is based largely upon theory that was derived from data for passenger vehicles. It was the purpose of this analysis to determine whether these theories are confirmed by data concerning school bus crashes in Virginia and several other states.

Fatalities Occurring on the Interstate System in Other States

The most current and reliable in-depth information on school bus crashes is collected by the National Transportation Safety Board (NTSB). This agency specializes in performing in-depth investigations of all types of transportation-related accidents. The data presented here were drawn from the TRB Special Report 222 (TRB, 1989), in which the NTSB augments standardized data from the Fatal Accident Reporting System with other information from state and local police departments, state directors of pupil transportation, and private accident investigators.

Between 1982 and 1986, there were 26 fatal crashes involving school buses in which there were in-bus fatalities. (Summaries of all 26 appear in Appendix C.) Of these, 5 occurred on interstate highways and are summarized here:

1. February 1982: A 1981 Type I* school bus was westbound on an interstate highway. The driver ran off the right side of

---

*Type I school buses in the TRB report were defined as "vehicles that are designed and built as school buses and that have a GVWR greater than 10,000 lbs" (TRB, 1989). This definition differs slightly from that of the NHTSA, which states that Type I school buses are those that have a seating capacity of more than 16 people (NHTSA, 1974).

the road, went down an embankment, skidded on the right of a concrete drainage ditch, and struck a concrete abutment..

2. October 1982: A 1977 Type I school bus was southbound in the right lane of a six-lane divided interstate highway. A southbound passenger vehicle traveling in the middle lane at high speed struck the bus on the left side. The school bus swerved to the left, went through a guardrail and across a body of water in the median, and overturned on its left side after striking a second median guardrail that protected the northbound lanes.

3. June 1985: A Type I school bus traveling on an activity trip at approximately 45 mph was southbound on an interstate highway when it struck a tractor semitrailer that had stalled in the right lane. The driver was apparently not paying proper attention since he was trying to read a note on the seat to his right.

4. November 1985: A 1979 Type I school bus was traveling at an estimated speed of 75 mph on an interstate highway when the driver lost control, striking a guardrail and the concrete base of a sign support. During the collision, the body and chassis separated.

5. December 1985: A 1974 Type I school bus was traveling eastbound approximately 40 mph in the right lane of an interstate highway. The bus was struck from behind by a tractor semitrailer, knocked into a guardrail and bridge piers, and overturned. The outer body panels were torn apart, leaving a hole in the right side and roof of the bus.

These accidents illustrate several points. First, very few school bus accidents resulting in in-bus fatalities occur on interstate highways. For example, no in-bus school bus fatalities occurred in the nation on any road system during 1986. Second, the outcome of school bus crashes can be affected by many variables, not just speed. For instance, the results of the first three of these five crashes were affected by such factors as the location of roadside obstacles, inattention on the part of the driver, and the presence of a stalled vehicle.

The last two crashes, however, exemplify the types of crashes potentially relating to the speed issues and theories discussed in this report. In the fourth case, a bus traveling at an excessive speed, much higher than the prevailing speed limit at the time, crashed into a fixed object. Had the crash occurred at a lower speed, the impact velocity would have been lower and the injuries might not have been so severe. However, this bus was traveling at a speed of 75 mph, far outside the

speeds being considered in this study. In the fifth crash, a bus traveling 40 mph, slower than the free-flowing traffic, was struck from behind by a tractor trailer. This is the type of crash that may occur when the travel speeds of various vehicle types vary significantly.

Again, the objectives of this study included establishing speed limits for school buses with the intent that (1) school buses should travel at speeds close enough to other traffic to minimize passing interactions and (2) school buses should travel at speeds slow enough to minimize the injuries resulting from crashes that do occur. Unfortunately, there is no clear convergence of evidence from these data or the literature to indicate the optimal speed limit at which both speed variance and theoretical crash probability are minimized.

Virginia's Accident Data

There are three questions that must be answered when examining Virginia school bus accident data:

1. Is there any indication that there is currently an accident problem for the interstate highway system related to variations in speed (e.g., a predominance of passing and rear-end accidents)?

2. Is there any evidence in the accident data that increasing the speed limit for school buses from 45 mph would result in a marked increase in the severity of accidents?

3. Is there any evidence that increasing the speed limit for school buses would result in fewer overtaking and passing interactions, theoretically reducing the probability of school bus accidents?

In answering these questions, an attempt was made to normalize accident data, or to take the number of miles traveled by school buses, and thus, their exposure to accidents, into consideration. Unfortunately, figures on average daily travel are not routinely collected for school buses in Virginia, so mileage factors such as vehicle miles of travel are unavailable. As part of the opinion polling of school bus drivers and administrators, these individuals were asked to estimate the mileage and length of regular route and activity trips taken each year, along with the number of students transported. Unfortunately, this request was quite difficult for both groups to comply with, and in many cases, these questions went unanswered. When this information was provided, estimates calculated were so variable that they could not be used to calculate accident rates. Therefore, all accident analyses were performed using raw numbers of accidents rather than rates that take exposures into consideration.

As shown in Table 5, over the three-year period prior to the change in the rural interstate highway speed limit for passenger vehicles, only 10 crashes occurred on Virginia's interstate highways. These crashes accounted for only four tenths of 1 percent of all school bus crashes in Virginia. Thus, it is difficult to draw any conclusions from these data other than the conclusion that there is not a substantial school bus crash problem for Virginia's interstate highways. As shown in Table 6, there were no fatalities reported for school buses on interstate highways in Virginia. Table 7 shows that nonfatal crashes were more likely to occur when a bus was traveling at speeds 25 mph or less, even on interstate highways.

TABLE 5

Number of School Bus Crashes by Location

Location	No. Crashes (%)
Interstate Highway	10 (0.4)
Primary Highway	298 (12.2)
Secondary Road	991 (40.7)
City/Town Street	1012 (41.6)
School Facility	123 (5.0)

TABLE 6

Severity of School Bus Crashes by Location

Location	No. Fatal Crashes (%)	No. Injury Crashes (%)	No. Non-injury Crashes (%)
Interstate Highway	0	3 (30.0)	7 (70.0)
Primary Highway	2 (0.7)	75 (25.3)	219 (74.0)
Secondary Road	4 (0.4)	184 (18.7)	797 (80.9)
City/Town Street	4 (0.4)	170 (16.9)	834 (82.7)
School Facility	0	4 (3.3)	118 (96.7)

TABLE 7

Speed of School Buses Involved in Crashes by Location

	Speed			
Location	0-25 mph (%)	26-35 mph (%)	36-45 mph (%)	46 mph and over (%)
Interstate Highway	5 (50.0)	1 (10.0)	4 (40.0)	0
Primary Highway	249 (83.6)	35 (11.7)	6 (2.0)	8 (2.7)
Secondary Road	845 (85.3)	106 (10.7)	4 (0.4)	36 (3.6)
City/Town Street	946 (93.5)	42 (4.2)	1 (0.1)	23 (2.3)
School Facility	121 (98.3)	---	---	2 (1.6)

In addition, if the speed limit differential between school buses and other traffic was a factor in these accidents, one would expect a preponderance of sideswipe and rear-end accidents. Indeed, as seen in Table 8, these maneuvers were involved in 80 percent of interstate highway accidents involving school buses, but they accounted for only 40 percent of the crashes on primary roads and 24 percent of those on secondary roads. Interestingly, although it was speculated that much of the travel time logged on interstate highways was by activity buses that needed to travel long distances quickly, this was not substantiated by the accident data (see Table 9). About 80 percent of school bus accidents on interstate highways in Virginia involved regular route buses. The reader is cautioned that there are too few interstate crashes under consideration to draw definite conclusions; however, the data do indicate that regular route school buses as well as activity trip buses are at some, though minimal, risk for crashes on interstate highways.

TABLE 8

School Bus Crash Configurations by Location

Location	Sideswipe--Same Direction (%)	Rear End--Vehicle Striking Bus (%)	Other Collision (%)
Interstate Highway	4 (40.0)	4 (40.0)	2 (20.0)
Primary Highway	32 (10.7)	87 (29.2)	179 (60.1)
Secondary Road	69 (7.0)	173 (17.5)	749 (75.5)
City/Town Street	129 (12.7)	207 (20.5)	676 (66.8)
School Facility	21 (17.1)	9 (7.3)	93 (75.6)

TABLE 9

School Bus Route Type by Location for School Bus Crashes

Location	Regular Route (%)	Other Route (%)
Interstate Highway	8 (80.0)	2 (20.0)
Primary Highway	275 (92.3)	23 (7.7)
Secondary Road	951 (96.1)	39 (3.9)
City/Town Street	954 (94.9)	51 (5.1)
School Facility	100 (81.3)	23 (18.7)

Table 7 also shows that it is unlikely that there are substantial problems on non-interstate roads related to maximum speed limit policies for school buses. On the primary highways, 83.6 percent of school bus crashes occurred at speeds of 25 mph or less, and only 4.7 percent (14 crashes) of the three-year total occurred at speeds in excess of 35 mph. If the maximum speed limit created a problem on primary highways, it should have been manifested by an increased number of crashes occurring when the school bus was traveling at its maximum speed. Thus, a substantial speed limit-related crash problem cannot be documented for primary highways from these data, nor can such a problem be documented for secondary roads or for city or town streets.

In an attempt to determine whether the increase in the speed limit for passenger vehicles on July 1, 1988, had an impact on the incidence of school bus accidents on interstate highways, an in-depth analysis was conducted of all school bus accidents on interstate highways between September 1985 and May 1989. (Descriptions of these accidents appear in Appendix D.) Most of these accidents, both prior to and after the change in the maximum speed limit, resulted in no major injuries. Prior to the change, only 3 of the 10 accidents resulted in injury. Of the five persons injured on school buses in crashes prior to the speed limit change for passenger vehicles, four were drivers or chaperones and the identity of the fifth person was unknown. After the speed limit change, two individuals, a driver and a student, were injured in separate school bus crashes on Virginia's interstate highways. Thus, in the past four school years, only seven people have been injured and none has been killed in interstate school bus crashes in Virginia. These data indicate that traffic accidents on the interstate highways have posed very little threat to students in recent years, even after the speed limit for passenger vehicles was increased to 65 mph.

Next, the location and configuration of these crashes were considered. If the increased speed limit differential between passenger vehicles and school buses had increased the probability of accidents, the number of accidents would have been expected to increase. This appears to be the case, since during the three previous school years, 10 accidents occurred compared to 7 during the one school year after the change was made. These numbers, however, are very small and could reflect random fluctuations rather than a trend. It would take considerably more accident data, collected over a longer period of time, to allow this determination. However, if accident probability did increase, then perhaps accident characteristics mirror this change. Assuming that the probability did increase, one would expect more accidents in which vehicles other than school buses were traveling faster than school buses and either rear-ended or sideswiped school buses. As seen in Table 10, prior to the change in the rural interstate highway speed limit for passenger vehicles, the most common type of collision involved a vehicle and a school bus in a sideswipe or angle-type

TABLE 10

School Bus Interstate Highway Crash Configuration:
September 1985 - May 1989

Configuration	9/85 - 5/88 Before Change	6/88 - 5/89 After Change
Other Vehicle Rear-Ends Bus	3	1
Bus Rear-Ends Other Vehicle	0	4
Sideswipe or Angle	4	1
Bus Strikes Bus	1	1
Other Collision	2	0

accident. The next most common involved the other vehicles rear-ending school buses. These two accident types did not increase after the school bus/passenger vehicle speed limit differential was increased. In fact, after the speed limit change, school buses more often rear-ended other vehicles rather than the other way around. Hence, although there were relatively few rural interstate crashes both before and after the speed limit for passenger vehicles was increased on rural interstate highways, configuration data do not support arguments that the increased speed limit differential resulted in more crashes.

Table 11 shows that other vehicles involved in school bus crashes more often were traveling 25 mph or less in the "after" time period than in the "before" period. In addition, after the change in the speed limit, school buses or other vehicles were more often stopped at the time of the accident (see Table 12). Thus, accident-related speed data do not support arguments that the increased speed limit differential contributed to an increase in school bus crashes on Virginia's interstate highways. Table 13 shows that approximately 40 percent of the school bus crashes on Virginia's interstate highways occurred on or near interchanges. Thus, it appears that one inherent characteristic of school buses, their inability to change velocity quickly, may be a major factor involved in school bus accidents.

TABLE 11

School Bus and Other Vehicle Speeds in Interstate Highway Crashes: September 1985 - May 1989

	School Buses		Other Vehicles*	
Speed	Before Change	After Change	Before Change	After Change
0-25	5	5	3	5
26-35	1	0	0	0
36-45	4	1	0	0
46+	0	1	3	1
Not Stated	---	---	3	0

*Total numbers do not agree because two school buses collided in two accidents (one before and one after).

TABLE 12

Vehicle Movement During School Bus Interstate Highway Crashes: September 1985 - May 1989

Conditions	Before Change (%)	After Change (%)
Bus Stopped	2 (20.0)	2 (28.6)
Other Vehicle Stopped	0	3 (42.9)
Neither Stopped	8 (80.0)	2 (28.6)

Finally, a major fear about a speed limit differential for school buses is that very large vehicles might strike a bus from behind, thereby causing serious injuries to students. As seen in Table 14, almost all interstate highway school bus accidents involved cars and none involved large trucks. In fact, the only large vehicles to strike school buses in the "before" and "after" periods were other school buses.

TABLE 13

Location of School Bus Interstate Highway Crashes:
September 1985 - May 1989

Location	Before Change (%)	After Change (%)
On Interstate	5 (50.0)	4 (57.1)
On or Near Entrance/ Exit Ramp	4 (40.0)	3 (42.9)
At Toll Booth	1 (10.0)	0

TABLE 14

Other Vehicle Types Involved in School Bus Interstate Highway Crashes:
September 1985 - May 1989

Vehicle Type	Before Change (%)	After Change (%)
Car	8 (80.0)	5 (71.4)
Pickup Truck	1 (10.0)	1 (14.3)
Large Truck	0	0
School Bus	1 (10.0)	1 (14.3)

In summary, although there was an increase in the numbers of crashes involving school buses on the interstate highway system, crash configuration data do not support the notion that these increases were attributable to the increased speed limit differential. However, there may be too few crashes in this sample to allow a determination of the impact of the increased speed limit differential. Thus, the reader is cautioned against drawing conclusions from these data since so few and such minor school bus interstate highway accidents occurred.

Because the number of school bus accidents occurring on interstate highways was so small, data from several other states were examined.

These states were chosen because they provided school bus accident data for a variety of speed limit differentials on rural interstate highways. If changing the speed limit on rural interstate highways increased speed limit differentials, then accident probability would also be expected to increase. Thus, those states with school bus speed limit differentials would be expected to have an increased number of accidents on rural interstate highways, but those without differentials should have experienced no change.

As seen in Table 15, in all states, the number of school bus accidents decreased or stayed the same on rural interstate highways, regardless of speed limit differentials. The number of school bus accidents on urban interstate highways, which tend to be more prevalent in the other states than in Virginia, either remained the same or increased slightly. From these data, it appears that, as in Virginia, there are very few school bus accidents on rural interstate highways in these other states. Although these states tend to have more school bus accidents on urban interstate highways than Virginia, there is no evidence that their speed limit policies contributed to an increase in school bus accidents on interstate highways. Thus, based on data from Virginia and selected other states, there is no reason to believe that a substantial school bus accident problem exists for interstate highways and no reason to believe that changing speed limit policies would improve Virginia's already exemplary safety record.

Opinion Surveys

Each of the three groups surveyed during this study (pupil transportation administrators, school bus drivers, and police agencies and other special interest groups) were asked several questions in common in addition to other questions that were specifically tailored to the interests and expertise of the individual group. The first common question concerned the ideal maximum speed limit for school buses on interstate highways. All three groups preferred a 55 mph speed limit (see Figure 3).*

However, of the three groups, respondents from the police agencies/special interest groups were most in favor of 55 mph (75.6%) and the administrators were least in favor (63.2%). For urban interstate

---

*The data upon which Figures 3 through 6 are based appear in Appendix G.

TABLE 15

Number of School Bus Crashes on Interstate Highways
(Selected States)

A. Michigan (50 mph for school buses, 65 mph for others)

Differential - 15 mph	Before Speed Limit Change	After Speed Limit Change
Rural	15	11
Urban	22	32

B. Texas (50 mph for school buses, 65 mph for others)

Differential - 15 mph	Before Speed Limit Change	After Speed Limit Change
Rural	1	1
Urban	0	0

C. Illinois (65 mph for all)

Differential - 0 mph	Before Speed Limit Change	After Speed Limit Change
Rural	3	1
Urban	54	58

D. West Virginia (65 mph for all)

Differential - 0 mph	Before Speed Limit Change	After Speed Limit Change
Rural	1	0
Urban	11	17

E. Georgia (65 mph for school buses/cars, 55 mph for others)

Differential - 10 mph	Before Speed Limit Change	After Speed Limit Change
Rural	11	6
Urban	74	78

A. MSL change - 11/29/89 - Compares 9/86-8/87 with 9/87-8/88
B. MSL change - 05/08/87 - Compares Calendar 86 with Calendar 88
C. MSL change - 05/09/87 - Compares 5/86-4/87 with 5/87-4/88
D. MSL change - 05/01/88 - Compares Calendar 87 with Calendar 88
E. MSL change - 02/88 - Compares Calendar 86 with Calendar 88

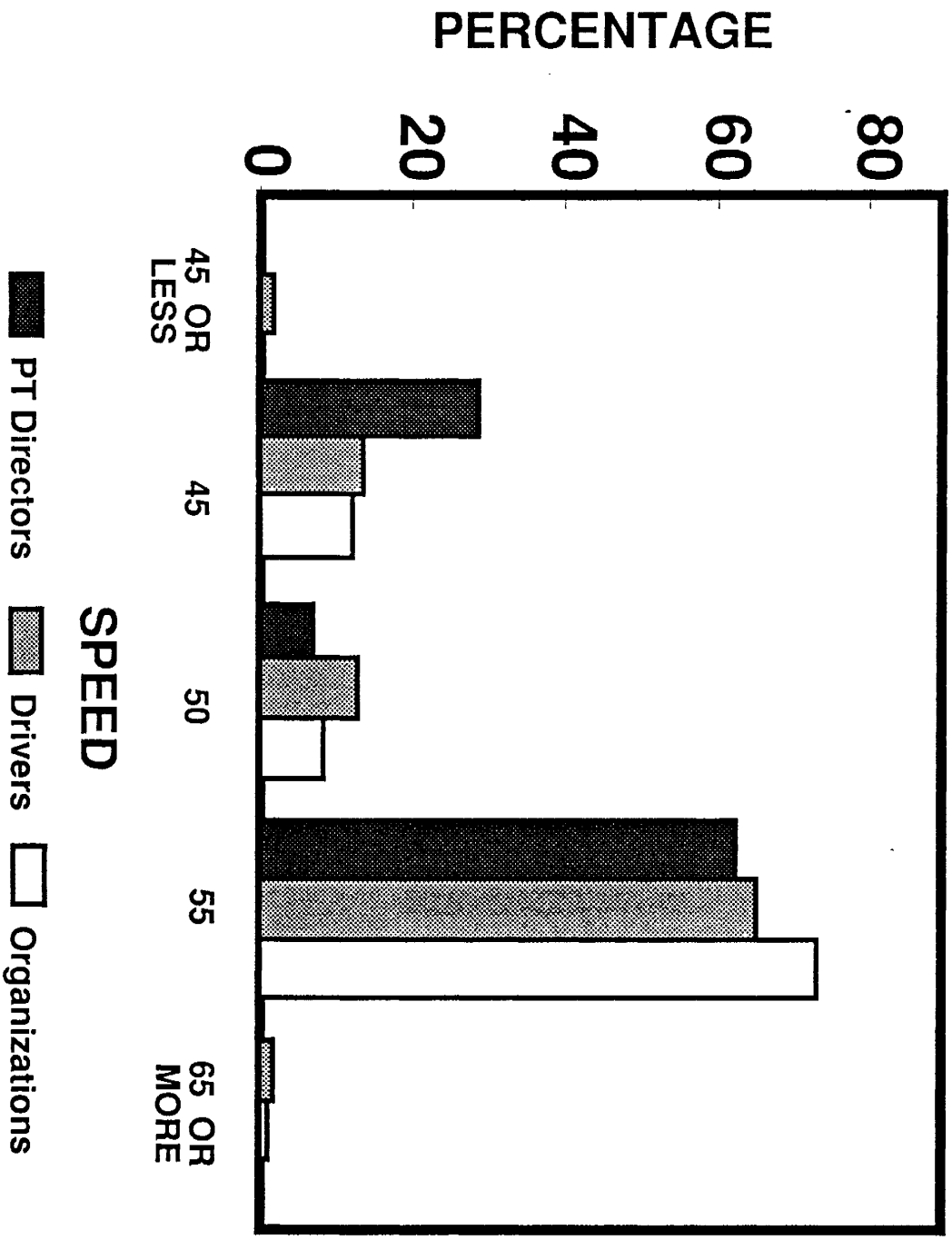


Figure 3: Preferred Rural Interstate Highway Speed Limit

highways and other roads with a 55 mph speed limit, a majority of administrators preferred a 45 mph speed limit (see Figure 4). For urban interstate highways, more bus drivers and police agencies/special interest groups preferred a 45 mph speed limit, but this was not by a clear majority--in both groups, 35 percent of the respondents preferred the 55 mph speed limit as opposed to between 40 percent and 47 percent, respectively, preferring 45 mph. The differences between groups on both of these questions were statistically significant at $p < .05$.

The three groups of respondents were also questioned concerning whether speed limits for activity buses should differ from limits for regular-route buses (see Table 16). Again, administrators' and bus drivers' responses were similar: about 74 percent preferred that the speed limits remain different. Police agencies/special interest groups were fairly evenly divided between the two options.

A number of questions were asked concerning whether it would be possible to prohibit the use of regular-route or activity buses on interstate highways and whether there was support for such an option. The vast majority of administrators (93%) and a lesser majority of drivers (69%) felt that it was possible to route regular morning and evening school buses away from interstate highways; however, neither group supported such a move (see Table 17). Concerning activity trips, a 71 percent majority of the administrators felt that it was possible to ban activity buses from interstate highways, but a 55 percent majority of the bus drivers felt that it was not possible (see Table 18). Both groups, however, strongly opposed rerouting activity buses off interstate highways.

The questions asked of each group specific to their particular interests and expertise are summarized below.

TABLE 16

Should the Maximum Speed Limit for Activity Buses Differ From That for School Buses on Regular Routes?

Response	Pupil Transp. Directors	Bus Drivers	Police Agencies/ Special Interest Groups
Yes	92 (73.6)*	356 (74.8)	37 (51.4)
No	33 (24.6)	120 (25.2)	35 (48.6)

*$\chi^2 = 17.19$; $p < .01$.

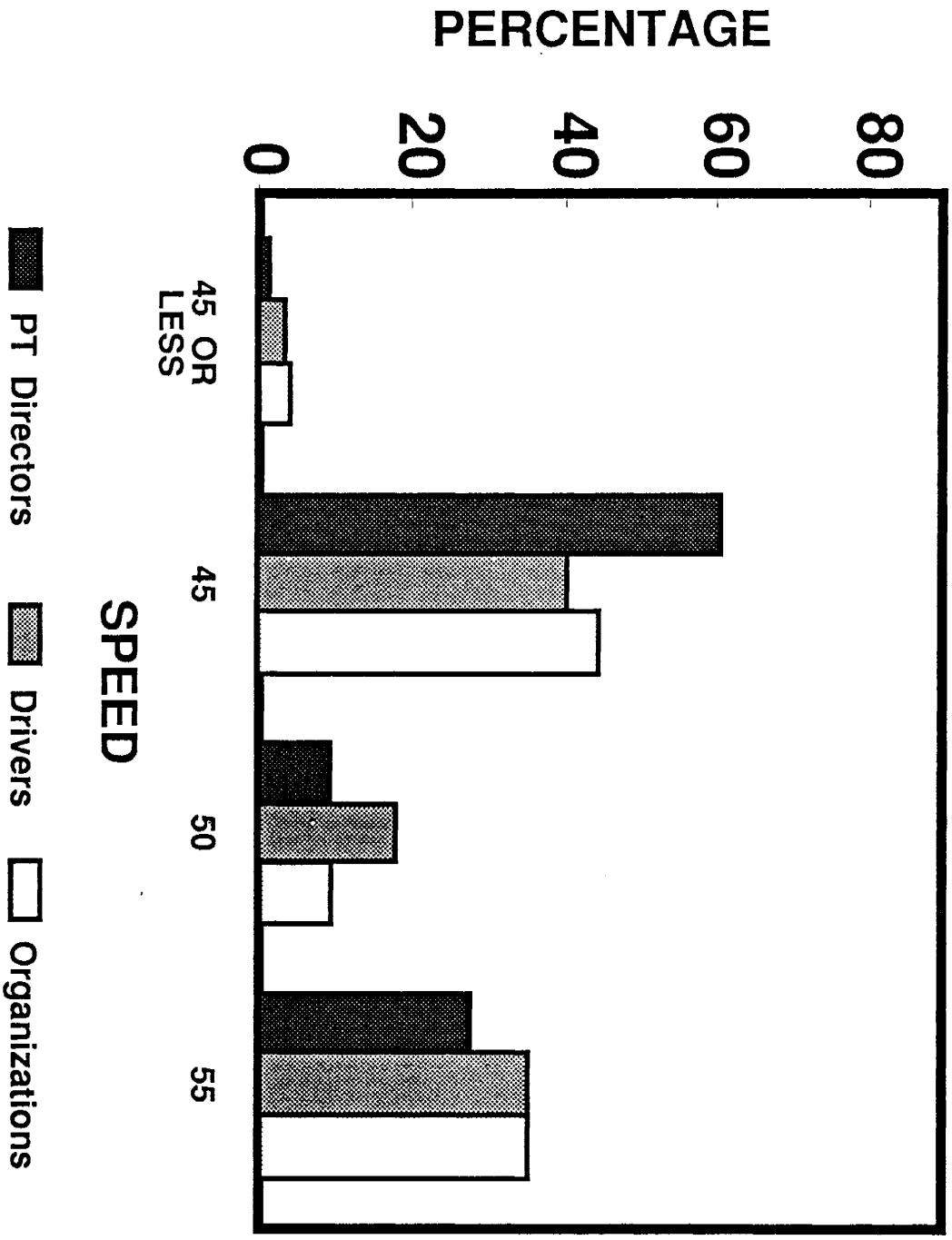


Figure 4: Preferred Urban Interstate Highway Speed Limit

TABLE 17

Responses Concerning Regular Bus Routes

Possible To Route Regular School Bus Trips on Non-Interstate Highways?

Response	Pupil Transp. Directors	Bus Drivers
Yes	103 (93.6)*	297 (68.6)
No	7 (6.4)	136 (31.4)

*χ^2 = 27.08; $p < .01$.

Support Prohibiting Regular Route Buses on Interstate Highways?

Response	Pupil Transp. Directors	Bus Drivers
Yes	30 (26.8)*	177 (40.8)
No	82 (73.2)	257 (59.2)

*χ^2 = 6.82; $p < .01$.

TABLE 18

Responses Concerning Activity Bus Routes

Possible To Route Activity Bus Trips on Non-Interstate Highways?

Response	Pupil Transp. Directors	Bus Drivers
Yes	87 (71.3)*	192 (45.4)
No	35 (28.7)	231 (54.6)

*χ^2 = 24.43; $p < .01$.

Support Prohibiting Activity Buses on Interstate Highways?

Response	Pupil Transp. Directors	Bus Drivers	Police Agencies/ Special Interest Groups
Yes	11 (8.9)*	53 (11.7)	7 (8.9)
No	113 (91.1)	400 (88.3)	72 (91.1)

*χ^2 = 1.16; not significant.

Police Agencies and Special Interest Groups

Any consideration of speed limits necessarily involves enforcement. Although one aspect of the enforcement of school bus speed limits is internal (the DOE enforces the use of a speed governor to control travel speeds), external enforcement by police agencies is also a factor in controlling school bus speeds. Since many of the special interest groups represented the interests of enforcement personnel, police agencies were asked whether the current limits, differentiated by the location of the bus and type of trip, were easy or difficult to enforce. If such laws were deemed difficult to enforce, an attempt to make changes to simplify detection and enforcement might be necessary. Table 19, however, shows that the majority of enforcement personnel (71%) felt that the current laws were easy to enforce.

TABLE 19

Ease of Enforcing Current School Bus Speed Limits

Category	Number of Responses (%)
Easy To Enforce	40 (71.4)
Difficult To Enforce	16 (28.6)

School Bus Drivers

School bus drivers were asked whether school buses could safely or adequately operate on different road systems or over varying terrain. When asked whether school buses could safely travel at 45 mph on the different road systems, the majority of drivers felt that buses could safely travel the rural interstate, urban interstate, and primary highways, but not the secondary roads (see Figures 5 and 6). However, the drivers felt that they could safely operate on rural and urban interstate highways at 55 mph, but that 55 mph was too high for primary and secondary roads. With regard to climbing speeds, a slight majority (54.5%) felt they could handle hills at 45 mph but not at 55 mph (see Table 20).

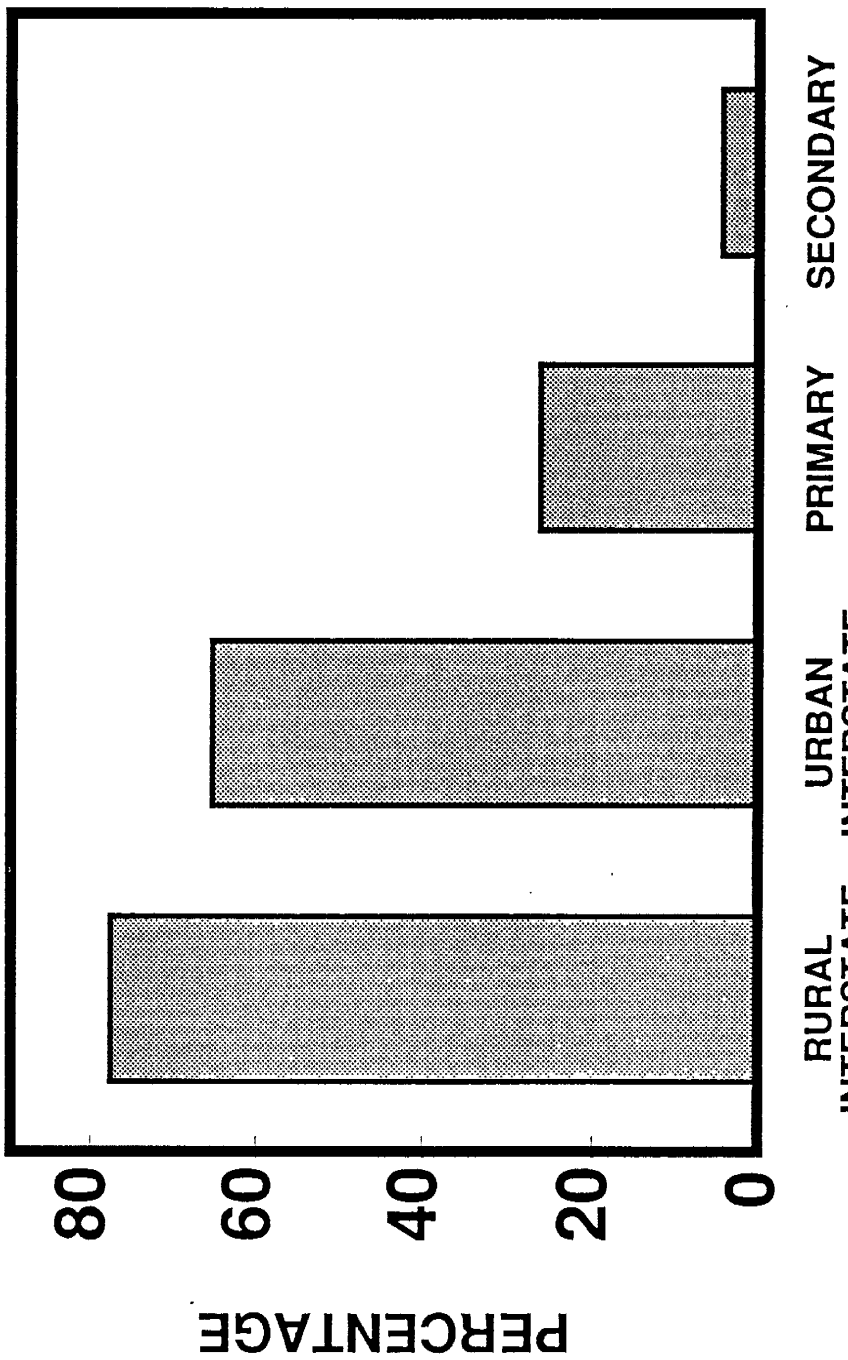


Figure 5: Safely Travel at 55 mph (School Bus Driver Opinion)

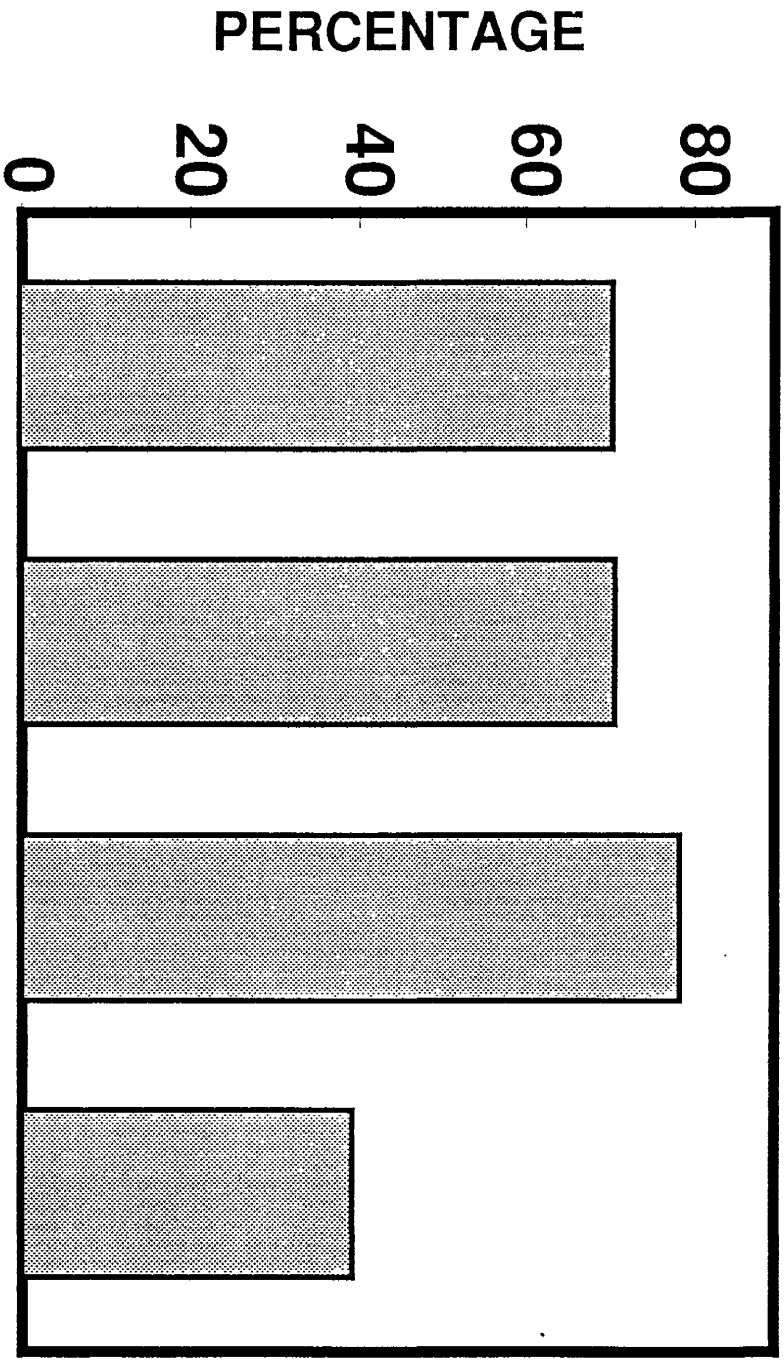


Figure 6: Safely Travel at 45 mph (School Bus Driver Opinion)

TABLE 20

School Bus Climbing Ability:
Can School Buses Adequately Go Up Hills At:

Speed	Yes	No
45 mph	255 (54.5)*	213 (45.5)
55 mph	217 (47.2)	243 (52.8)

*$\chi^2 = 4.67$; $p < .05$.

Finally, drivers were asked the maximum speed at which their buses could travel with a working speed governor installed. Table 21 shows that about 79 percent said their bus could operate at 45 mph, with about 11 percent stating that the bus could travel faster and about 10 percent stating that the bus could run only slower.

TABLE 21

Top Speed That Buses Can Travel With a Working Speed Governor

Speed	No. Responses (%)
35	10 (2.1)
40	40 (8.4)
45	375 (78.9)
50	42 (8.8)
55 or over	8 (1.8)

Summary of Opinion Surveys

In summary, a majority of each of the three groups supported a 55 mph speed limit on rural interstate highways but preferred 45 mph for urban interstate highways. The majority of school bus drivers felt that

their buses could travel safely on rural interstate highways at 55 mph, even though a majority felt that their vehicle could not adequately climb hills at that speed. The drivers' perceptions supported the hypothesis developed from the speed survey that a speed governor tends to limit travel speeds to about 45 mph. Both administrators and bus drivers were opposed to routing regular and activity buses off interstate highways.

Risk Assessment Modeling

One of the objectives of this study was to provide a risk assessment model that local pupil transportation directors could use in order to decide whether to route school buses onto interstate highways or use parallel routes. The need for this model was further brought to light through discussions that some members of the study team had with one director from an urban area in the Commonwealth. This director worried that routing his regular-route school buses onto congested and fast-moving urban interstate highways would place his students at risk. However, he feared that using the parallel primary route would pose an even greater risk. A risk assessment model would provide this director and others with the information needed to make decisions based on crash data rather than on "gut feelings."

As was shown by the crash data, school bus crashes on interstate highways are rare events. Thus, school bus crash data alone would not provide enough information by which administrators could adequately assess the risks associated with these decisions. Given that there are limitations of the data, the study team sought another measure of risk. Total accident rates could have been used, but they are influenced largely by passenger vehicle accidents and may not adequately take into account the special characteristics of school buses. Since trucks have handling characteristics more similar to school buses than passenger vehicles, truck accident rates might be used to assess the relative risks associated with school bus travel on interstate highways as opposed to alternative routes.

From the annual Virginia Department of Transportation (VDOT) source document "Summary of Accident Data," accident data for crashes involving all vehicle types on Virginia's interstate and primary highways were gathered. Truck accident data were derived from raw accident data using the same formula used by the VDOT:

$$\text{Accident rate} = \frac{\text{No. accidents} \times 100{,}000{,}000}{\text{Length of section in miles} \times \text{Average Daily Traffic} \times 365}$$

A risk assessment analysis of interstate and parallel primary highway data was prepared for this report (see Appendix H). In this analysis, truck accident rates for interstate highways were compared to

rates for parallel segments of the primary highway to determine whether routing on one system is less safe than routing on the other. Interestingly, rates were almost always lower on interstate routes than on corresponding parallel primary routes. Further, when all vehicle crashes were considered, the relative safety of the interstate highways was even greater. The few cases in which either a total accident rate or a truck accident rate was lower for the parallel primary route than for the interstate highway were considered aberrations since this instance was never replicated across two years. These findings combined with the fact that there are few interstate highway crashes involving school buses suggest that traveling on interstate highways whenever possible provides an optimal level of safety. Thus, although this analysis was designed to provide Pupil Transportation Directors with a model to help them decide when to route school buses on interstate and primary highways, this model was not needed. Travel on interstate highways was deemed safer than travel on parallel primary routes.

DISCUSSION

The guiding principle of this study was to identify speed limit policies that would ensure the safe travel of students on school buses. A synthesis of the data collected for this report suggests clear directions for some policy issues, but directions for other issues remain unclear. One thing that is clear is that it is impossible to eliminate the risk for injury or death for on school bus travel; however, when other types of travel are considered, school bus travel is extremely safe.

A comparison of the accident rates for interstate highways and for parallel primary routes indicates that interstate highway travel is the safer of the two options. This conclusion is consistent with the opinions expressed by school bus drivers and administrators, who indicated a reluctance to ban school buses from interstate highways even though such a ban might feasibly be implemented.

Although routing school buses onto interstate highways whenever possible is desirable and should function to enhance the excellent overall safety record for school bus travel, placing school buses on high-speed highways comes with its own risks. On the one hand, the faster any vehicle travels, the greater the potential risk for injury or death if the vehicle is involved in a crash. A vehicle traveling far slower than the prevailing speed on a highway, however, is at a higher risk for being involved in a crash. Thus, neither slower nor faster is always better. Each has its own advantages and disadvantages.

Options

When considering possible options, the study team examined the possibility of setting different maximum speed limits for activity-trip and regular-route school buses on non-interstate highways. From this investigation, the data did not suggest that different speed policies were necessary. There was also very little evidence found in the accident data or the opinion survey data to indicate a need for changing the speed limits on non-interstate highways. Likewise, the study team found no evidence to indicate that activity-trip and regular-route school buses should have different maximum speed limits on interstate highways. The evidence was mixed on whether there is a need to increase the maximum speed limit for school buses at all, regardless of the conditions under which it would be increased.

The majority of school administrators, school bus drivers, and police agencies/special interest groups indicated a desire to increase the rural interstate highway speed limit to 55 mph for school buses but to leave the urban interstate speed limit at 45 mph. The options presented below, however, could be considered for both rural and urban interstate highways. Although there is a difference between urban and rural interstate highway speed limits for passenger vehicles, the school bus speed limit is the same. Thus, continuing a uniform speed limit for school buses on rural and urban interstate highways would be consistent with current policies.

All of the options concerning school bus speed limits were considered carefully, and several were eliminated. The options of allowing school buses to travel a maximum of 60 mph or 65 mph on rural interstate highways were eliminated. Although 22 states have a maximum speed limit of 65 mph and 1 has a maximum of 60 mph, these limits would be more than that for trucks in Virginia. Thus, a higher speed limit for school buses than for trucks would not reflect and would be inconsistent with the rationale for establishing a truck speed limit of 55 mph. A speed limit of 65 mph would also be inconsistent with Virginia's tradition of establishing a speed limit for school buses lower than that for passenger vehicles.

The option of lowering the current 45 mph maximum speed limit for school buses was also eliminated. Virginia is already among 4 states with a 45 mph maximum speed limit, and only South Carolina has a lower maximum speed limit. There is no indication from accident and speed data that Virginia's school buses are currently traveling too fast. Thus, lowering the maximum speed limit would likely increase crash risk without much benefit in terms of reduced potential crash severity. The options that remained are summarized below.

Option 1: Increase School Bus Speed Limits to 55 mph

One option is to permit school buses to travel 55 mph on rural interstate highways only or on both urban and rural interstate highways.

An advantage of this option is that the change would result in more uniformity with other states' statutes or regulations. Further, based on previous research, the accident probability should decrease since the differential between passenger vehicle, truck, and school bus speed limits would be reduced. Virginia has traditionally had a speed limit differential between school buses and passenger vehicles, and this change would be in keeping with this tradition--the truck/school bus speed differential would be eliminated, but the passenger vehicle/school bus differential of 10 mph would remain. This alternative was strongly supported for rural interstate highways by administrators, bus drivers, and police agencies/special interest groups. In addition, assuming that such a change were made, travel times for school bus riders on interstate highways would be reduced, thereby reducing the time students were exposed to accidents. Finally, this option would eliminate the current three-tiered speed limit on interstate highways, thus simplifying speed limit laws.

This option also has a number of disadvantages. One disadvantage is that since school buses would be traveling faster than they currently are, accident severity would likely increase. This increase would likely be most severe in school bus/large truck accidents. However, since no school bus/large truck accidents have occurred on Virginia's interstate highways in the last four years, such occurrences may be unlikely. Having two tiers of speed limits would still allow much speed variance in the system, theoretically increasing crash probability over that for a uniform speed limit. Also, it is unclear whether eliminating the three-tiered system would be a benefit. There have been very few crashes under the policy, and the police claim that they have no unusual trouble enforcing it. Based on these advantages and disadvantages, the desirability of this option appears mixed.

One clear-cut problem associated with increasing the speed limit for school buses on interstate highways involves speed governors. Increasing the speed limit to 55 mph would also necessitate increasing the maximum speed allowed by a governor. Currently a governor is set at 45 mph, which is the maximum speed school buses can legally travel on other systems. If a governor is set at 55 mph, however, it will allow speeds higher than the maximum limits set for school buses on all other roadway systems. Thus, the effectiveness of a governor in controlling speeds on other systems would be reduced, and school bus speeds might increase on other road systems, particularly primary highways.

Option 2: Increase School Bus Speed Limits to 50 mph

Another option would be to increase the maximum speed limit for school buses to 50 mph on rural interstate highways only or on both urban and rural interstate highways.

An advantage of this change is that increasing the maximum speed limit to 50 mph on interstate highways is supported by speed theory in that it would reduce the speed limit differential and therefore should reduce accident probability. However, this same theory lends more support to a 55 mph speed limit for school buses.

According to the theory, a disadvantage of raising the speed limit for school buses to 50 mph is that accident severity should increase, but not as much as it would with a 55 mph speed limit. Increasing the school bus speed limit to 50 mph would also reduce the effectiveness of a speed governor on other roadway systems, but again, not as much as with a 55 mph speed limit. In addition, increasing the minimum speed limit to 50 mph would not eliminate the three-tiered speed limit system for rural interstate highways. Finally, very few other states have adopted a 50 mph interstate speed limit for school buses, and this policy would therefore do little to increase the consistency of Virginia's statutes and regulations with those of other states.

Option 3: Maintain the School Bus Speed Limit at 45 mph

Another option would be to retain the 45 mph maximum speed limit for school buses on interstate highways.

An advantage of this option is that according to speed theory no increase in crash severity would result. Retaining the current speed limit would also maintain the effectiveness of a speed governor on other systems. Further, this option was mildly supported by opinion data; however, it did not receive as much support as 55 mph. Finally, retaining the current speed limit would maintain the status quo: changes in training, enforcement, or equipment would not be necessary.

A disadvantage of maintaining the current speed limit is that Virginia's policies concerning school bus speed limits are unlike those adopted by most other states. Under this option, Virginia would be among those states with the lowest maximum speed limit in the nation. Thus, retaining the current speed limit would not promote uniformity in state school bus speed limit policies. Further, this option would do nothing to mitigate the problem of the 20 mph speed differential, which, according to theory, should result in increased crash probability. However, there are so few crashes occurring on interstate highways now that efforts to reduce crash probability further may be futile.

CONCLUSIONS AND RECOMMENDATIONS

Choosing an option in a situation like this one, where no alternative stands out from the rest as the best solution, is difficult. Each option could be adopted for urban or rural interstate highways with mixed results, thus making a decision difficult.

It is possible to look at the laws and regulations of other states and conclude that Virginia is clearly out of step with the rest of the nation. A total of 41 other states allow school buses to travel 55 mph on urban interstate highways, and 23 states allow higher speeds on rural interstate highways. However, to be more like the other states is not sufficient reason to change the speed limit for school buses. Because this issue has not been studied before, and because objective, scientific reasoning has not generally been the basis for changing school bus speed limit policy, it is possible that Virginia's policy is actually better in terms of safety than that of most other states. Thus, the fact that other states have adopted higher speed limits for their school buses is not a compelling reason for Virginia to raise the speed limit for its school buses.

The opinions of school administrators, bus drivers, and police agencies/special interest groups all indicated a desire for a higher speed limit for school buses on rural interstate highways. Although it may be possible to travel safely at a higher speed, the conservative philosophy adopted by the study team dictates that things should remain the same unless there are compelling reasons to change. Many of those who responded to the opinion surveys believed that the speed limit for school buses needed to be raised because they feared that slow-moving school buses would be struck from the rear. They particularly feared that a large truck would strike a school bus from the rear. Although these fears are based on the drivers' experiences in traffic, the accident data did not support the hypothesis that a speed limit-related crash problem has developed.

When accident data are examined, one conclusion is inevitable--there is currently only a minimal school bus crash problem for Virginia's interstate highways. With one year of experience with a 20 mph speed limit differential, the increase in the number of school bus crashes does not appear to be related to school bus speed limits set for that system on Virginia's interstate highways. Thus, this real-world experience indicates that the school bus accident problem predicted by speed theory has not yet materialized.

There are intriguing arguments that provide compelling evidence that a change in school bus speed limits would not be desirable. First, because a speed governor mechanically limits the maximum speed that a school bus may travel, an increase in the speed limit and a subsequent

increase in the maximum speed that a governor would allow might create a potential for crash-related problems on non-interstate highways. Even if the majority of school bus drivers would comply with the 45 mph maximum speed limit regardless of the presence of a speed governor, it is likely that a minority of drivers would exceed maximum limits if a governor were not installed. In fact, based on the school bus speed survey, several drivers violated the interstate highway speed limit, with one traveling at 58 mph. A governor thus has the potential of influencing school bus drivers who might otherwise violate the speed laws. Also, although there were only a few crashes on the interstate highways involving school buses, slow acceleration and deceleration were identified as being factors in a number of those crashes. Since stopping distance, and therefore deceleration time, is decreased at slower speeds, retaining the 45 mph speed limit for school buses should minimize deceleration-related school bus crashes.

One of the fears of all those involved in this study was that a catastrophic crash involving a school bus could occur on Virginia's interstate highways after the study was completed. Chance factors could come together to result in a catastrophic crash that would attract public attention. Because school bus crashes involve young children, the public tends to have strong feelings concerning school bus crashes. Even in cases where no fault or direct cause can be identified, there is considerable public pressure to do something to prevent crashes. In the event of such a crash, the theoretical rationale for raising the school bus speed limit would be lost on the public. Additionally, if the speed limit were raised, it is possible that the speed of the school bus would have contributed to the severity of the crash. Such evidence would not be lost on the public. Thus, action without compelling evidence of the existence of a school bus accident problem for interstate highways would be perceived as a contributing factor.

If no change is made and a catastrophic crash occurs, the lower speed limit for school buses could be identified as a cause of the accident. However, at this time although there are theoretical elements of risk, the data do not indicate that Virginia has a substantial school bus crash problem for its interstate highways. Further, an analysis of Virginia's crash data does not indicate that any of Virginia's speed policies have created problems that endanger the lives of children who travel in these vehicles.

Therefore, it is the conclusion of the study team that there is no compelling reason to change the maximum speed limits for school buses on Virginia's highways.

Obviously, conditions may change on the interstate highways and problems yet undetected may materialize. Thus, the study team strongly recommends that school bus accident data, particularly for crashes that

occur on interstate highways, be reviewed periodically to determine whether a crash problem related to the speed limit for school buses develops and whether action is warranted in the future. To make school bus accident data more accessible and to make conducting this and future analyses easier and more efficient, it is recommended that the Office of Pupil Transportation begin working toward the development of a computerized school bus accident database. Software such as the Microcomputer Traffic Records System (MTRS), which was developed by VTRC personnel, might be modified to accept school bus accident data and would provide standardized output summarizing accident characteristics.

REFERENCES

Garber, N. J., and Gadirau, R., "Speed Variance and Its Influence on Accidents," AAA Foundation for Traffic Safety, Washington, D.C. (1988).

Hauer, E., "Accidents, Overtaking and Speed Control," Accident Analysis and Prevention, Volume 3, Pergamon Press (1971).

Johnson, P., Klein, T., Levy, P., and Maxwell, D., "The Effectiveness of the 55 mph National Maximum Speed Limit," National Highway Traffic Safety Administration, U.S. Department of Transportation, Washington, D.C. (1976).

Kelley, B., "Speed and Car Crashworthiness: Unfixing a Great Gulf," Insurance Institute for Highway Safety, Washington, D.C. (November 1973).

Michaels, R., and Schneider, C., "The Energy Crisis, Characteristics of Traffic Flows and Highway Safety," Accident Analysis and Prevention, Volume 8, Pergamon Press (1976).

National Highway Traffic Safety Administration, Highway Safety Programs Manual 17, Washington, D.C. (1974).

Research Triangle Institute, "Speed and Accidents," Durham, North Carolina (June 20, 1976).

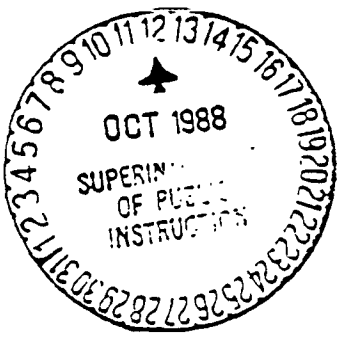
Solomon, D., "Accidents on Main Rural Highways Related to Speed, Driver and Vehicle," Federal Highway Administration, U.S. Department of Transportation, Washington, D.C. (1968).

Transportation Research Board, "Improving School Bus Safety," Special Report 222, Washington, D.C. (1989).

Virginia Department of Transportation, "Summary of Accident Data," Richmond, Virginia (1986, 1987).

APPENDIX A

Agreement Between the Virginia Department of Education and the Virginia Transportation Research Council



COMMONWEALTH of VIRGINIA

DEPARTMENT OF TRANSPORTATION
1401 EAST BROAD STREET
RICHMOND, 23219

RAY D. PETHTEL
COMMISSIONER

OSCAR K. MABRY
DEPUTY COMMISSIONER

September 28, 1988

1343

Dr. S. John Davis
Superintendent of Public Instruction
Monroe Building
101 North 14th Street
Richmond, Va 23219

RE: Memorandum of Agreement

Dear Dr. Davis:

As per this memorandum of agreement, the Research Council will be undertaking a study of school bus speed limits on Virginia highways. The purpose of this study is to document any problems with school bus transportation of pupils resulting from Virginia's multitiered speed limit system. In particular, the Research Council will be examining the impact of school bus speed limits on school bus accident rates/severity. The final report will propose solutions to the problems identified.

Step 1 of the project involves the collection of school bus accident records in Virginia as well as other states. This phase will commence immediately upon receipt of your confirmation of this agreement. The target date for publication of the final report is September 15, 1989.

In conducting this study, the Research Council is working in conjunction with and on behalf of the Virginia Department of Education. As a result, by the terms of this letter agreement, the Department of Education shall reimburse the Research Council for any expenditures necessitated by the project up to a maximum amount of $35,849. Monthly invoices shall be submitted by the Research Council to the Department of Education for reimbursement up to the maximum amount specified. Furthermore, the Department of Education shall assist the Research Council in the conduct of the speed limit study by surveying the statutes, practices, and perceptions that local school divisions and other states have developed in response to school bus accidents.

If the terms of this agreement are acceptable to you, please sign and date the original copy of the letter where indicated and return to Mr. Howard H. Newlon, Jr., Director of the Research Council. We look forward to working with your department in this endeavor.

Sincerely,

Oscar K. Mabry
Deputy Commissioner

cc: Mr. Howard H. Newlon, Jr.

S. John Davis

10-14-88
Date

APPENDIX B

Survey Instrument--School Bus Speed Limit
Statutes and Regulations from the 50 States

COMMONWEALTH of VIRGINIA

DEPARTMENT OF EDUCATION
P.O. BOX 6Q
RICHMOND 23216-2060

December 9, 1988

TO: State Directors/Administrators of School Transportation Programs

FROM: R. A. "Buster" Bynum
Associate Director, Pupil Transportation Service

SUBJECT: Survey of State Regulations and Laws on School Bus Speed Limits

The Virginia Department of Education, in conjunction with the Virginia Transportation Research Council, is studying the issue of optimal speed limits for school buses. Currently, Virginia law limits school buses to a maximum of 35 mph on regular routes, and 45 mph on trips with no pickups or discharges and on the interstate highway system. Because other vehicles on the highways may have a speed limit up to 20 mph faster than that of school buses, the possibility of accidents being caused by such a speed differential has caused some concern. On the other hand, there is concern that school buses may not be able to travel safely at higher speeds.

We are interested in finding out how other states have dealt with the issue of setting speed limits for school buses. We know that fifteen states besides Virginia have statutes dealing specifically with school bus speed limits. The remaining states have statutory provisions that allow school bus speed limits to be established through administrative regulations. We would appreciate your cooperation in advising us of the situation in your state. Please take a few minutes to complete the enclosed questionnaire. Should you have questions about this study, you may call me at (804) 225-2037 or Mr. Jack Jernigan at (804) 293-1909.

When we complete the study in the fall of 1989, we will forward a copy to you. Thank you for your assistance.

RAB:sdc

enclosure

SURVEY OF STATE REGULATIONS AND LAWS ON SCHOOL BUS SPEED LIMITS

State: _____

Person & Title Responding: _____

Address: _____

_____

_____

Phone No:( ) _____

1. Does your state have a statute that specifically regulates school bus speeds? Yes _____ No _____

   If yes, what are the provisions of it? _____

   _____

   _____

   _____

   _____

   _____

   _____

   Statute/code citation _____

2. Does your state have administrative regulations limiting school bus speeds? Yes _____ No _____

   If yes, what are the details of those regulations? _____

   _____

   _____

   _____

   _____

   Chapter, title, section _____

1350

School Bus Survey State _____
Page 2

3. Does your state have any law or administrative regulation prohibiting school buses from using the interstate highways or any other classification of highways? Yes _____ No _____

   If yes, what are the details of the laws or regulations? _____

   _____

   _____

   _____

   _____

   Statute/code/chapter & section _____

4. Does your state require a control device (governor) for school bus speeds? Yes _____ No _____

   If yes, at what speed is the device set? _____

5. Any other comments you wish to make about school bus speed limits _____

   _____

   _____

   _____

   _____

RETURN TO: Mr. Jack D. Jernigan
Virginia Transportation Research Council
P.O. Box 3817, University Station
Charlottesville, Virginia 22903

APPENDIX C

Descriptions of In-Bus Fatal Accidents--1982 to 1986

APPENDIX C

Supplemental Information on the 26 Fatal School Bus Accidents That Resulted in Passenger Deaths

Analyses of 26 fatal school bus accidents (1982–1986) that resulted in the deaths of school bus passengers are presented in Chapter 3. Additional information on the accidents was provided by the National Transportation Safety Board (NTSB), state and local police departments, state directors of pupil transportation services, and private accident investigators and is presented in this appendix. Although this information is useful in characterizing the nature of fatal school bus accidents and suggests the effectiveness of some safety measures, it is often not possible to make conclusive judgments about whether particular fatalities could have been avoided if a specific safety measure had been used. Even with intensive post-crash investigation, such judgments are difficult and subject to error.

It should be noted that two of the school bus accident reports taken from the Fatal Accident Reporting System (FARS) files were miscoded. The school bus in Case 12 was used to transport retarded adult citizens. The bus was painted blue and was not equipped with standard school bus safety features such as flashing red signal lights or stop signal arms. The school bus in Case 23 was

an intercity bus used to transport students, typically adult students, to and from the Ozark Bible Institute.

In another accident (Case 2), a school bus passenger exited the rear emergency door of a school bus and was struck by a truck in the opposing travel lane. Three other school bus passengers in Cases 5, 17, and 18 were killed when they fell or jumped from moving school buses.

All 26 of the school bus accidents reported in this appendix occurred between 1982 and 1985. No school bus accidents that resulted in the deaths of school bus passengers were recorded in the United States in 1986.

1. January 25, 1982 (Texas Department of Public Safety Accident Report 2026774). A 1975, Type I school bus was traveling south on a county road. Due to apparent brake failure, the bus ran through a "T" intersection, jumped a bar ditch, and came to rest in a plowed field. The bus did not overturn. Photographic evidence suggests that external damage to the bus was not extensive (Figure C-1).

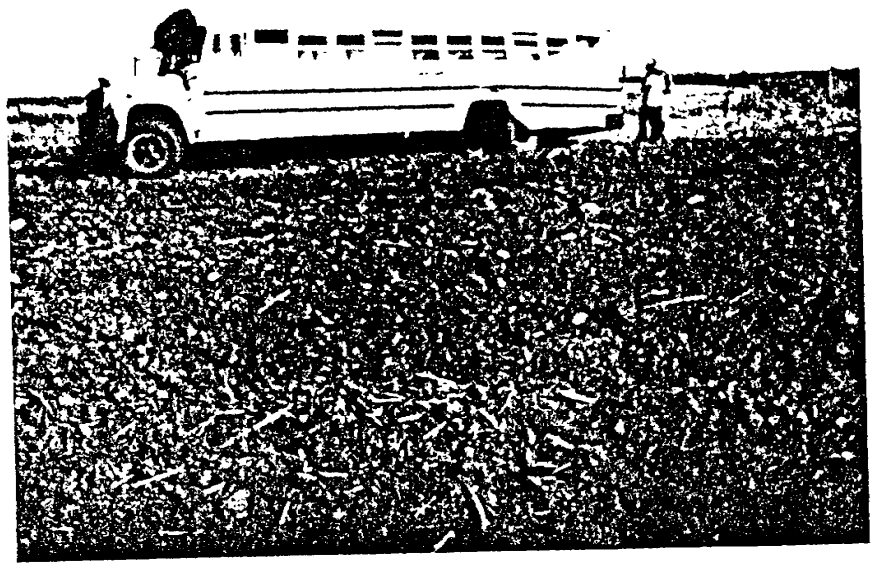


FIGURE C-1 A 1975, Type I school bus ran through intersection, jumped a bar ditch, and came to rest in a plowed field. *Photograph courtesy* James Wright, Corpus Christi Independent School District.

A 7-year-old male passenger died from injuries suffered inside the bus during the accident; he was not ejected from the bus. The bus driver and seven passengers received nonincapacitating (B-level) injuries; four passengers received incapacitating (A-level) injuries.

2. February 15, 1982 (Alorton, Illinois Police Accident Report 7869014). A Type I school bus (date of manufacture unknown) was westbound on a two-lane road. The school bus driver reported hearing a buzzer that indicated the rear emergency door was open. The driver stopped the bus. A 14-year-old girl who exited the bus through the rear emergency door was apparently struck and killed by an eastbound truck.

(3) February 20, 1982 (Missouri State Highway Patrol Traffic Accident Report 60651). A 1981, Type I school bus was westbound on an Interstate highway (Figure C-2). "Accident apparently occurred when driver . . . ran off right side of roadway, down an embankment, skidded on right side down a concrete drainage ditch and struck a concrete abutment." A 59-year-old female passenger who was not ejected was killed. The driver and 14 other passengers received disabling injuries. One passenger received an evident (nondisabling) injury. The remaining 26 passengers were not injured.

4. March 25, 1982 (Louisiana Department of Public Safety State Computer 0161279). A 1978, Type I school bus headed south had stopped at an intersection of a two-lane state highway. On entering the intersection, the bus was struck on the right side by an eastbound tractor semitrailer. Thirty of the 51 students on board the bus were injured; an 8-year-old male was killed.

5. June 4, 1982 [North Carolina Traffic Accident Report (Caldwell County)]. Memorandum from Wilbur F. Woodall, Jr., North Carolina Division of Motor Vehicles, to Worth McDonald, June 8, 1982.

"On Friday, June 4, 1982, bus #85 (1974 Ford) was traveling south on RP 1001. This area of the county had been experiencing heavy rain all afternoon, and [it] was raining at the time of the accident. There were only four passengers on the bus at the time of the accident.

"The driver of the bus . . . asked one of the passengers . . . to wipe the right side of the windshield which was fogging up during the heavy rain. After cleaning the windshield . . . [the student] . . . stayed in front of the bars with his back against the front door.

"Another student . . . was sitting on the front seat and accidentally hit the door safety latch. As the door opened . . . [the student] . . . fell out and was caught on a metal spike underneath the bus." The student, a 15-year-old male, was struck and killed by the rear wheels of the bus.

6. June 17, 1982 (Georgia Department of Public Safety Accident Report 21-113-82). A 1978, Type I school bus carrying 66 passengers was eastbound on a county dirt road. The bus stopped at a stop sign and then entered an intersection, where it was struck on the right side by a northbound truck

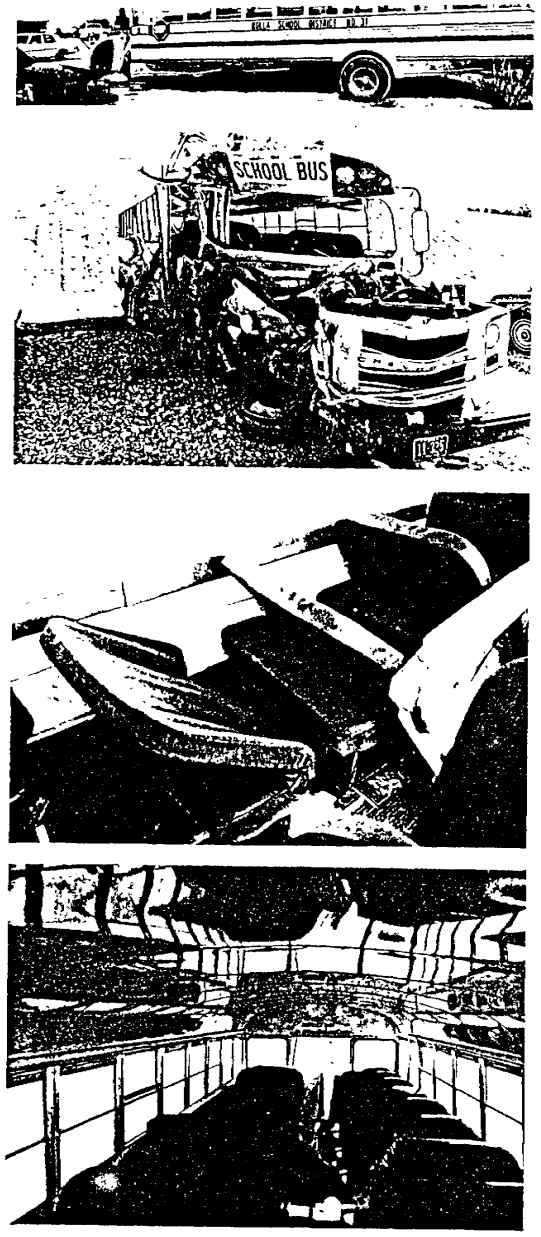


FIGURE C-2 A 1981, Type I school bus ran off roadway, skidded on right side down a concrete drainage ditch, and struck a concrete abutment. *Photographs courtesy* Judy Bellinger, Missouri Department of Elementary and Secondary Education.

traveling an estimated speed of 40 to 45 mph. A 9-year-old male in the second-row, right-side, window seat was killed.

(7) October 8, 1982 (Texas Department of Public Safety Accident Report 2342877). A 1977, Type I school bus was southbound in the right lane on a six-lane, divided Interstate highway. A southbound passenger car traveling in the middle lane at high speed struck the bus on the left side. The school bus swerved to the left, went through a guardrail and across a body of water in the median, and overturned on its left side after striking a second median guardrail that protected the northbound lanes. A 14-year-old female passenger in the bus was killed. Five other passengers sustained incapacitating injuries, and 15 sustained nonincapacitating injuries.

8. December 8, 1982 (Georgia Department of Public Safety Accident Report 6-315-82). A 1982, Type I bus northbound on a two-lane state highway was preparing to stop to unload passengers. The driver of a southbound passenger car, upon seeing the stopping school bus, braked and skidded. The passenger car was struck from the rear by a tractor semitrailer, which jackknifed and struck the school bus in the front and along the left front side. The school bus rotated to the right and turned over on its right side. A 6-year-old female seated in the front row on the right side of the bus was killed.

9. February 24, 1983 (NTSB 1983a, 17). A 1972, Type I school bus was southbound on a two-lane state highway. A northbound dump truck crossed the centerline and struck the school bus head-on. A female school bus passenger seated in the row behind the driver was killed. "In this accident, at least 18 passengers sustained Abbreviated Injury Scale (AIS) Level 1 (minor) and 2 (moderate) injuries to the head and facial areas. Blood transfers were noted on the exposed metal seatbacks and seatframes."

10. March 9, 1983 (Texas Department of Public Safety Accident Report 3110025). A tractor semitrailer was southbound on a four-lane road that had a posted speed limit of 40 mph. The tractor semitrailer jackknifed on a wet surface and crossed the centerline, striking a passenger car in the left rear. The tractor semitrailer continued across the northbound lanes and struck a northbound 1978, Type I school bus nearly head-on. A 14-year-old female school bus passenger was killed.

11. March 25, 1983 (NTSB 1983b). A 1975, Type I school bus was used to transport 31 high school students and 6 teachers on a school-sponsored outing. At 5:40 a.m., the bus rounded a horizontal curve at too great a speed, slid into the opposing lane, and proceeded across a stop-controlled "T" intersection. On the other side of the intersecting road, the bus overturned in a drainage ditch. The driver, four teachers, and four students were killed. The remaining 29 passengers (2 teachers and 27 students) received varying levels of injury.

~~12~~. April 5, 1983 (NTSB 1984a) (New York State Police Accident Report 3-214430). A 1982, Type I bus *painted blue* and operated by the New York

State Association for Retarded Children (NYSARC) was involved in a head-on accident with a 2-ton flatbed truck. The bus driver and four adult passengers (ages 34, 56, 24, and 39) were killed. "The NYSARC had sought to order the bus with flashing red lights and to have it painted schoolbus chrome yellow with black trim for added safety, but the request was denied by the New York State Department of Transportation (NYSDOT) on the grounds that the passengers were not children and the vehicle was not to be used for school transportation purposes" (NTSB 1984a, 12). In denying the request to have the bus painted yellow, the NYSDOT cited Federal Highway Safety Program Standard 17, which prohibits buses from being painted yellow and marked as school buses if they are not used for school transportation.

This accident was erroneously coded in FARS as a school bus accident. "[I]t was determined that the accident of April 5, 1983 (3-214430) was not a school vehicle accident."[1]

13. January 10, 1984 (NTSB 1984b). A 1979, Type I school bus was westbound on a two-lane state highway that had a speed limit of 50 mph. The bus was struck on the left front by a tractor semitrailer that crossed the centerline as the result of a previous collision. The bus overturned and came to rest on its roof, off the road (Figure C-3). The bus driver and a 5-year-old male sitting in the front-row, window seat behind the driver were killed. Twelve other students passengers were injured; two were not injured.

14. January 21, 1984 (NTSB 1984c). A 1977, Type I school bus (manufactured before April 1, 1977), returning from a school-sponsored outing, was westbound on a two-lane highway when it struck an eastbound tank truck (a tractor-semitrailer-full trailer) that had jackknifed and crossed into the westbound lane. The truck was stationary at the time of the collision, which occurred at 6:18 p.m.

On impact a fire started in the engine compartment and stairwell of the bus, apparently from aviation fuel carried by the tank truck. The school bus driver and eight passengers (all seated in the first two rows of the bus) were killed. All nine vehicle occupants apparently died of mechanical trauma, not fire or smoke inhalation. The remaining 18 passengers sustained various levels of injuries.

15. May 9, 1984 (NTSB 1984d). A 1977, Type I school bus (manufactured before April 1, 1977) had stopped (with red flashing lights activated) on a two-lane highway to unload students. A tractor pulling a flatbed semitrailer approached the stopped bus from the rear at 45 to 55 mph and attempted to pass. A corn planter positioned on the flatbed and extending 4 ft beyond the right edge struck the bus in the left rear and sliced into the occupant compartment. Two children were decapitated and two others died of head injuries.

FIGURE C-3 A 1979, Type I school bus struck on the left front by a tractor semitrailer. *Photograph courtesy* Rehoboth Police Department, Massachusetts.

16. September 27, 1984 (NTSB 1985a). A westbound 1968, Type I school bus with four passengers on board stalled on a railroad track at a grade crossing. On the approach of a northbound train, two students fled the bus. The other two were killed when the bus was struck in the left side by the oncoming train. Both passengers and the driver, who was seriously injured, were ejected.

17. October 25, 1984 (Florida Traffic Accident Report 035569623). A 1977, Type I school bus (month of manufacture unknown) was southbound on Timberlane Road. Occupant (an 11-year-old male student) for unknown reasons released the latch on the emergency door at the rear of the bus and leaped onto the pavement, striking his head. He died the following day.

18. January 25, 1985 (New Mexico State Police Accident Report 563284). A 1977, Type I school bus (month of manufacture unknown) had stalled on a forest road as a result of an electrical malfunction. The driver removed the key from the ignition and went to a nearby residence to call for assistance, leaving the children on the bus. While the driver was away, the bus began rolling down a slight grade. Several children then jumped from the moving bus. One child, a 7-year-old girl, died when she was struck by the moving bus.

19. April 22, 1985 (Minnesota Department of Public Safety Accident Report 51120001). A 1984, Type I school bus had just stopped at a stop-controlled intersection. As the westbound bus pulled into the intersection, it was struck on the right side by a southbound tractor semitrailer carrying a load of lumber. The bus overturned, and a 15-year-old female passenger was killed (Figure C-4). Six other children were injured.

20. April 29, 1985 (NTSB 1985b). A 1977, Type I school bus (manufactured after April 1, 1977) stopped on a two-lane highway with warning lights flashing to unload passengers. The bus was struck from the rear by a tractor semitrailer hauling 99 head of cattle and traveling at an estimated speed of 59 mph (Figure C-5). Two of the 32 school bus passengers were killed; 26 others sustained minor to serious injuries.

21. May 31, 1985 (NTSB 1986). A 1982, Type I school bus was traveling south at 32 mph on a two-lane highway on the outside of a horizontal curve. A northbound tractor semitrailer struck the bus on the left side near the front. The "skin" of the bus was torn open and passengers in the first three rows of seats behind the driver were ejected. Six passengers were killed and 22 were injured.

22. June 7, 1985 (CHP 1985). A Type I school bus (date of manufacture unknown) traveling at approximately 45 mph was southbound on an Interstate

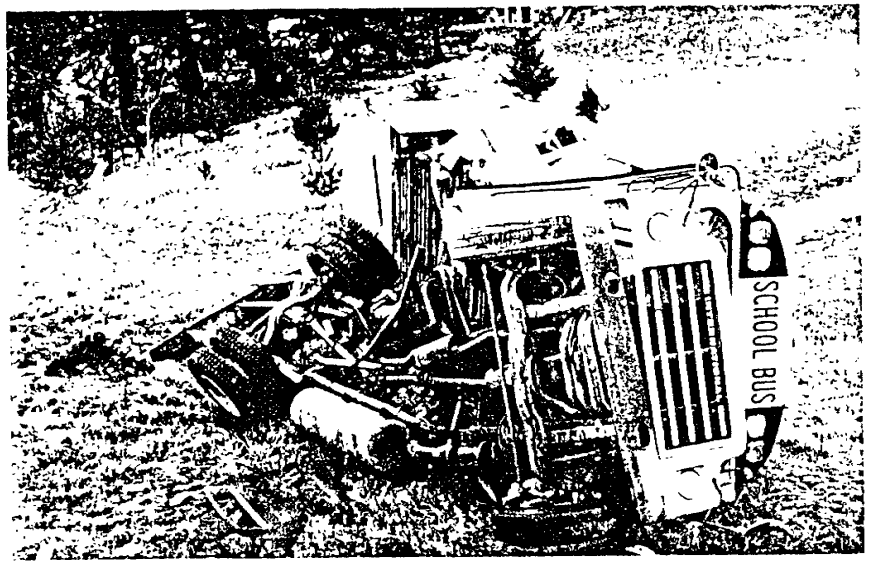


FIGURE C-4 A 1984, Type I school bus struck on the right side by a tractor semitrailer loaded with lumber. *Photograph courtesy* Minnesota Department of Education.

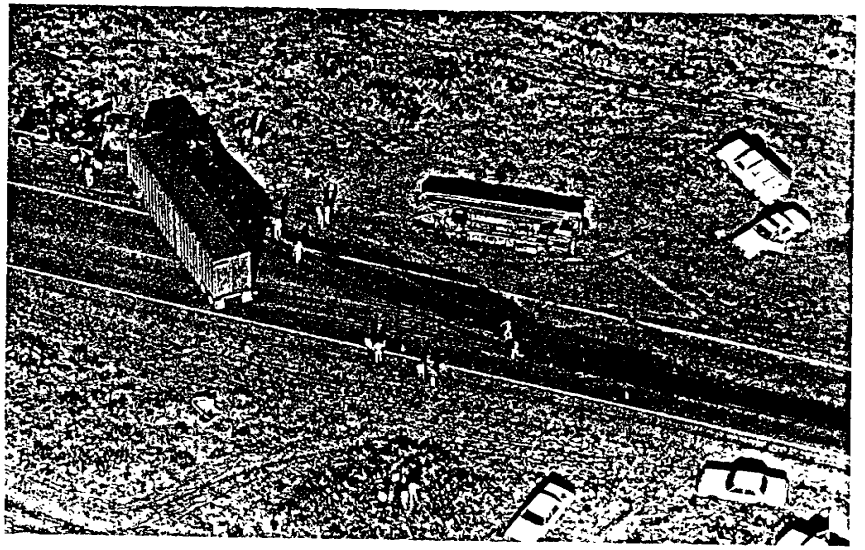


FIGURE C-5 A 1977, Type I school bus struck from the rear by a tractor semitrailer traveling approximately 59 mph. *Photograph courtesy* Brian Winters, *Arizona Daily Sun*.

highway when it struck a tractor semitrailer that had stalled in the right lane. The emergency flashers on the stalled truck had been activated. The school bus was transporting more than 70 sixth grade students and their chaperons to a school-sponsored activity. The accident occurred at approximately 10:20 a.m. Traffic was relatively light and visibility was good.

The accident may have resulted from driver inattention: "He was apparently reading directions on a note, which was on his seat under his right leg" (Kinney 1988).

23. September 13, 1985 (NTSB 1987a). This accident was erroneously coded in FARS as a fatal school bus accident. The bus in question was a ". . . 1965 General Motors Corporation (GMC) Model PD-4106, 2-axle, intercity coach. . . ." (NTSB 1987a, 13). The passengers were aged 17 to 66 and were students at the Ozark Bible Institute.

In this accident the bus overturned; nine passengers were ejected and four were killed.

24. October 10, 1985 (New York State Police Accident Report 5-546268). The driver of a 1978, Type I school bus lost control of the vehicle on a two-lane road while traveling at a speed of approximately 15 to 20 mph. The bus ran down a sloped embankment on the left side of the road, came back across the road, and ran down the right-side embankment before coming to a stop.

FIGURE C-6 A 1974, Type I school bus struck from the rear by a tractor semitrailer and knocked into a guardrail and bridge piers before it overturned. *Photographs courtesy* Michigan Department of State Police.

Damage to the bus was relatively minor. Of the 15 passengers on board, 9 escaped injury, 5 received minor injuries, and 1 was killed.

> [I]n sharp contrast to the rest of the occupants, one boy received a fatal liver injury (severely lacerated liver). However, according to the pathologist, the boy was at higher risk to this type injury than other children because his liver was not a normal, healthy liver; the boy had an enlarged liver situated lower in the abdomen than normal. It is believed that during the accident sequence, this child who initially was not seated, was leaning over the seat back in front of him, and when the rear wheels bounced over the embankment, the seat back was accelerated sharply into the child's torso and inflicted the fatal injury. (NTSB 1987b, 103)

(25) November 11, 1985 (NTSB 1987c). A 1979, Type I school bus was traveling at an estimated speed of 75 mph on an Interstate highway when the driver lost control, striking a guardrail and the concrete base to a sign support. During the collision, the bus body and chassis separated. Two of the 13 passengers on board were killed.

(26) December 5, 1985 (Michigan Department of State Police Complaint 51-3403-85). A 1974, Type I school bus was traveling at about 40 mph east in the right lane of an Interstate highway. The bus was struck from behind by a tractor semitrailer and knocked into a guardrail and bridge piers; it then overturned (Figure C-6). The outer body panels were torn apart, leaving a gaping hole in the right side and roof of the bus. Four of the 23 passengers were killed and 17 others were injured.

Note

1. Letter from H. Shufon, Chief Clerk, Accident Records Bureau, State of New York Department of Motor Vehicles, Albany, New York, to TRB, August 16, 1988.

References

ABBREVIATIONS

CHP	California Highway Patrol
NTSB	National Transportation Safety Board

CHP. 1985. *Information Bulletin: Summary of School Bus Accident Statistics, Fiscal Year 1984/85*. Sacramento, Calif.

Kinney, R. 1988. Summary report of the June 7, 1985, accident made available to the committee on September 7, 1988, by Ron Kinney, Supervisor of School Transportation for the California Department of Education.

NTSB. 1983a. *Highway Accident Report—Collision of Humboldt County Dump Truck and Klamath-Trinity Unified District Schoolbus, State Route 96 near Willow Creek, California, Feb. 24, 1983.* Report NTSB/HAR-83/05. Washington, D.C.

NTSB. 1983b. *Highway Accident Report—Jonesboro School District Schoolbus Run-Off-Road and Overturn, State Highway 214 and State Highway 18, near Newport, Arkansas, March 25, 1983.* Report NTSB/HAR-83/3. Washington, D.C.

NTSB. 1984a. *Highway Accident Report—Valley Supply Co. Truck Towing Farm Plow/Anchor Motor Freight Inc. Car Carrier Truck/New York State Assoc. for Retarded Children Bus, Collision and Fire, State Route 8, near Holmesville, N.Y., April 5, 1983.* Report NTSB/HAR-84/01. Washington, D.C.

NTSB. 1984b. *Highway Accident Report—Collision of G&D Auto Sales, Inc., Tow Truck Towing Automobile, Branch Motor Express, Company Tractor-Semitrailer, Town of Rehoboth Schoolbus, Rehoboth, Massachusetts, January 10, 1984.* Report NTSB/HAR-84/05. Washington, D.C.

NTSB. 1984c. *Schoolbus/Truck Collision US2, Essex, Montana.* Report MKC84-M-SB18. Washington, D.C.

NTSB. 1984d. *Factual Report of Investigation Rochester, Missouri Rear-End Collision.* Report MKC84-H-SB25. Washington, D.C.

NTSB. 1985a. *Railroad/Highway Accident Report—Grade Crossing Collision of a Florida East Coast Railway Company Freight Train and an Indian River Academy Schoolbus, Port St. Lucie, Florida, September 27, 1984.* Report NTSB/RHR-85/01. Washington, D.C.

NTSB. 1985b. *Highway Accident Report—Collision of Tuba City School District School Bus and Bell Creek, Inc. Tractor-Semitrailer, US 160 near Tuba City, Arizona, April 29, 1985.* Report NTSB/HAR-85/06. Washington, D.C.

NTSB. 1986. *Highway Accident Report—Multiple Vehicle Collision and Fire, U.S. 13 Near Snow Hill, North Carolina, May 31, 1985.* Report NTSB/HAR-86/02. Washington, D.C.

NTSB. 1987a. *Highway Accident/Incident Summary Report—near Ackerly, Texas, July 20, 1985; Eureka Springs, Arkansas, September 13, 1985; and Bramwell, West Virginia, October 13, 1985.* Report NTSB/HAR-87/01/SUM. Washington, D.C.

NTSB. 1987b. *Safety Study—Crashworthiness of Large Poststandard Schoolbuses.* Report NTSB/SS-87/01. Washington, D.C.

NTSB. 1987c. *Schoolbus-Loss of Control and Collision with Guardrail and Sign Pillar, U.S. Highway 70 near Lucas and Hunt Road, St. Louis County, Missouri, November 11, 1985.* Report NTSB/HAR-87/02. Washington, D.C.

1360

APPENDIX D

Descriptions of School Bus Accidents Occurring on Virginia's Interstate Highways--1985 to 1988

VIRGINIA INTERSTATE HIGHWAY ACCIDENTS

1. February 10, 1986 (Richmond City): On a cloudy day, a 1973 model, 64-passenger bus with students on board was traveling on Powhite Parkway (I-95) at 45 mph when a pickup truck attempted to pass the bus. Traveling at approximately 55 mph, it struck the bus on the left rear side. A witness said that the bus swung into the other lane with no warning. The bus driver and one other person were injured.

2. May 6, 1986 (Henrico County): On a clear day, a 1978 model, 64-passenger bus with 45 students on board was stationary on the exit ramp between I-95 and I-64 when it was hit in the rear by a car. There were no injuries.

3. June 5, 1986 (Richmond City): A 1980 model, 64-passenger bus was traveling north at 20 mph on Powhite Parkway (I-95), coming out of the toll booths, when a car came from the right shoulder of the highway and hit the bus on the right rear bumper. The weather was clear, and there were no injuries and only minimal damage.

4. December 11, 1986 (Fairfax County): On a rainy day, a 1985 model, 34-passenger school bus with students on board was traveling on I-495 north at 40 mph in the far right lane. A car traveling at excessive speed in the second lane struck another car in the rear, causing the second car to spin around and hit the side of the school bus. There was one injury and only minor damage to the bus.

5. January 6, 1987 (Fairfax County): On a cloudy day, a 1975 model, 36-passenger bus was attempting to exit I-495 to I-66 when another car in the middle lane also attempted to exit and hit the bus in the side. There were no pupils on board and no injuries, but there was approximately $2,000 damage to the bus.

6. April 21, 1987 (Prince William County): A 1985 model, 34-passenger school bus was traveling approximately 15 mph on a clear day on I-66 in the far right lane. A car pulled out in front of it, and the bus hit it on the right fender. Students were on board, but there were no injuries and no damage to the bus.

7. May 12, 1987 (Isle of Wight County): Two 64-passenger school buses were traveling in the far right lane on I-64 at 45 mph when the first bus braked to avoid traffic and the second hit it in the rear. Both buses had passengers on board, and there were two injuries and moderate damage to the buses. The weather was clear.

8. June 3, 1987 (Prince William County): A 1985 model, 64-passenger bus carrying students was traveling in the far right lane of I-95 south at 25 mph when it was struck by a car trying to cut in from the extra rush hour lane. There were no injuries and no damage to the bus. It was raining.

9. September 17, 1987 (Portsmouth): On a clear day, a 1983 model, 64-passenger bus with students on board was stopped at a traffic signal on an exit ramp from I-264 when a car hit it in the rear. There were no injuries and only minor damage to the bus.

10. May 10, 1988 (Prince William County): On a clear day, a 1987 model, 64-passenger bus was attempting to enter I-495 north when it hit the rear fender of a car traveling in the slow lane. There were no injuries, and there was no damage to the bus.

11. July 1, 1988 (Arlington Public Schools): Two 64-passenger school buses collided with each other in a rear-end collision on I-395. No students were on board, and there were no injuries, though there was extensive damage to both buses. The weather was clear.

12. September 19, 1988 (Albemarle County): On a clear day, a 1985 model, 64-passenger school bus was exiting I-64 to Route 20 traveling at 5-10 mph when it rear-ended a car in front of it that had stopped for traffic at a "Yield" sign. Students were on board, but there were no injuries and only minor damage to the bus.

13. October 17, 1988 (James City County Public Schools): A 1986 model, 64-passenger school bus with students on board was traveling at 40 mph on I-64 east. When it slowed to exit, a car traveling at 65 mph hit the bus from behind. The driver of the car lost control of the vehicle, and it overturned. One student was injured, and there was moderate damage to the bus. It was a clear morning.

14. October 21, 1988 (Fairfax County): A 1978 model, 64-passenger bus was traveling south on I-395 at 25 mph when a pickup truck tried to cut in front of it. The bus changed lanes to avoid the truck, but another car, which had been following closely, hit the rear of the bus. There were no students on the bus and no injuries. It was raining.

15. February 7, 1989 (Fairfax County): A 1978 model, 64-passenger bus was on the ramp to I-66 East traveling at 10 mph when a car on I-66 spun around at the ramp entrance. A car in front of the bus stopped to avoid the bus, and the bus slid into the stopped car. No students were on board, and there were no injuries. The road surface was wet and icy.

16. May 18, 1989 (Chesterfield County): On a clear day, a 1985 model, 54-passenger bus was traveling south on I-95. The bus stopped because of traffic, and a car hit it from behind. There were students on board, but only the bus driver was injured.

17. May 22, 1989 (Newport News): On a clear day, a 1985 model, 64-passenger bus was traveling east on I-64 at 50 mph when the driver saw a car stalled in the lane. The driver tried to change lanes but hit the car in the left rear and spun it around. There were no injuries, although there were students on board. There was $1,700 damage to the bus.

APPENDIX E

Opinion Survey Questionnaires

- Pupil Transportation Administrators
- School Bus Drivers
- Special Interest Groups

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF EDUCATION
P.O. BOX 6Q
RICHMOND, VIRGINIA 23216

SUPTS. MEMO. NO. 11
February 8, 1989

Administrative

TO: Division Superintendents

FROM: S. John Davis, Superintendent of Public Instruction
M. E. Cale, Deputy Superintendent for Administration, Assessment and Financial Services (Acting)

SUBJECT: Survey of School Bus Speed Limits

The Virginia Department of Education, in conjunction with the Virginia Transportation Research Council (VTRC), is conducting a study of optimal speed limits for school buses on Virginia highways. Currently, Virginia law limits school buses to a maximum of 35 miles per hour (mph) on regular routes, and 45 mph on trips with no pickups or discharges and on the interstate highway system. Because other vehicles on the highways may have a speed limit up to 20 mph faster than that of school buses, the possibility of accidents being caused by such a speed differential has caused some basis for concern. Conversely, there is concern that school buses may not be able to travel safely at higher speeds.

The enclosed Administrator's Questionnaire on School Bus Speed Limits contains questions that, when answered and returned, will provide the Department and VTRC with data about the impact that the multitiered speed limits have on school bus safety in your school division. Please complete all questions with the answers that best describe your school system's experiences, recommendations, and rationale.

Please note that the Questionnaire is to be completed and returned in the enclosed self addressed envelope to: Mr. Jack Jernigan, Research Scientist, Virginia Transportation Research Council, P. O.. Box 3817, University Station, Charlottesville, Virginia 22903. All responses should be returned no later than February 24, 1989.

If you desire additional information or have questions concerning the study, please contact R. A. Bynum, Associate Director, Pupil Transportation Service at (804) 225-2037 or Mr. Jack Jernigan, Research Scientist, Virginia Transportation Research Council, at 804-293-1909.

SJD/MEC:ns
Enclosures

PUPIL TRANSPORTATION SURVEY

Administrator Questionnaire

February 1989

On the rural interstate highway system in Virginia, the maximum speed limit for school buses is 45 mph, but the maximum speed limit for trucks and other buses is 55 mph and that for passenger cars is 65 mph. On the urban interstate highways the speed limit for school buses is 45 mph and on other roads the maximum speed limit for school buses is 35 mph; however, school buses neither loading nor unloading passengers between the points of origin and destination have a maximum speed limit of 45 mph. We are interested in the impact these limits have on school bus safety. Please help us by filling out this questionnaire as completely as possible. **YOUR ANSWERS WILL BE HELD IN STRICTEST CONFIDENCE.**

Name _____ School Division _____

Phone No. ( ) _____

1. On the rural interstate system the maximum speed limit for passenger cars is 65 mph. The corresponding maximum speed limit for trucks is 55 mph, and the limit for school buses is 45 mph. What do you feel should be the maximum speed limit for school buses on the rural interstate system? (circle one)

   35 40 45 50 55 60 65

   Why do you feel this way?

   _____

   _____

   _____

2. On urban interstates and other primary roads that have a 55 mph speed limit for passenger cars, what do you feel the maximum speed limit should be for school buses? (circle one)

   35 40 45 50 55

   Why do you feel this way?

   _____

   _____

   _____

3. Do you feel the maximum speed limit for school buses should be different on regular routes than on special activity or field trips?

yes _____ no _____

Why do you feel this way?

_____

_____

_____

The next three questions deal with the planning of regular school bus routes to and from school in the morning and afternoon.

4. Please describe briefly how regular school bus routes are selected in your division. (If there is a written policy, please enclose a copy.)

_____

_____

_____

_____

_____

5. How many school buses use the interstate on regular routes? _____

6. In your division, is it possible to schedule school bus regular morning and afternoon routes on roads other than interstate highways? (check one)

yes _____ no _____

If yes, what alternative highways would you use?
If no, please state why this cannot be accomplished and proceed to question 8.

_____

_____

_____

7. If you have a choice between routing a regular school bus on an interstate highway or a primary highway, how do you make this choice?

_____

_____

_____

The next three questions concern the planning of routes for special activity or field trips.

8. Please describe briefly how bus routes for special activity trips are selected in your division. (If there is a written policy, please enclose a copy).

_____

_____

_____

_____

9. In your division, would it be possible to route school buses on special activity trips on roads other than interstate highways? (check one)

yes _____ no _____

If yes, what alternative highways would you use?
If no, please state why this cannot be accomplished and proceed to question 11.

_____

_____

_____

10. If you have a choice between routing a special activity or field trip school bus on an interstate highway or a primary highway, how do you make this choice?

_____

_____

_____

11. Would you support a prohibition of the use of school buses on interstate highways during regular morning and afternoon routes? (check one)

yes _____ no _____

Why do you feel this way?

_____

_____

_____

12. Would you support a prohibition of the use of school buses on interstate highways during special activity trips? (check one)

yes _____ no _____

Why do you feel this way?

_____

_____

_____

13. Please provide the following information (or an estimate, if necessary) concerning special activity trips (field trips, sporting events) taken in your division during the school year 1987/1988.

	Approved Yellow School Buses	School Activity Buses (Non-Yellow)	Charter/ Rental Vehicles	Other Vehicles
The total number of special activity trips (field trips, sporting events, etc.) taken in 1987/88.	_____	_____	_____	_____
The average number of pupils transported on such trips.	_____	_____	_____	_____
The average number of miles traveled on such trips.	_____	_____	_____	_____

	Approved Yellow School Buses	School Activity Buses (Non-yellow)	Charter/ Rental Vehicles	Other Vehicles
On such trips, the total mileage traveled on the interstate roads that now have a speed limit of 65 mph (for cars).	_____	_____	_____	_____
On such trips, the total mileage traveled on the interstate roads that still have a speed limit of 55 mph (for cars).	_____	_____	_____	_____
On such trips, the total mileage traveled on non-interstate routes with a 55 mph speed limit.	_____	_____	_____	_____

14. Please indicate the total number of vehicles used for the above mentioned trips (count each vehicle once)

_____ approved yellow school buses

_____ school activity buses (non-yellow)

_____ charter/rental vehicles

_____ other vehicles

15. In your division, who is in charge of collecting data on traffic accidents involving school buses?

Name _____ Address _____

_____

Phone No. ( ) _____

16. Do you have any additional questions or comments concerning school bus speed limits?

Thank you for the time and effort you have taken to respond to these questions. Without your help, we would not be able to determine the impact that speed limit changes may have on school bus safety. Please put your response in the enclosed postage paid envelope and return it to:

Mr. Jack Jernigan
Research Scientist
Virginia Transportation Research Council
P.O. Box 3817, University Station
Charlottesville, Virginia 22903

COMMONWEALTH of VIRGINIA

DEPARTMENT OF EDUCATION
P.O. BOX 60
RICHMOND 23216-2060

MEMORANDUM

May 15, 1989

TO: School Bus Drivers

FROM: R. A. Bynum RAB
Associate Director, Pupil Transportation Service

SUBJECT: Survey of School Bus Speed Limits

The Virginia Department of Education, in conjunction with the Virginia Transportation Research Council (VTRC), is conducting a study of optimal speed limits for school buses on Virginia highways. Because other vehicles on the highways may have a speed limit up to 20 mph faster than that of school buses, the possibility of accidents being caused by vehicles traveling at very different speeds has caused some concern. Conversely, there is concern that school buses may not be able to travel safely at higher speeds.

The enclosed Bus Drivers' Questionnaire on School Bus Speed Limits contains questions that, when answered and returned, will provide the Department and VTRC with your opinions about the impact that multitiered speed limits have on school bus safety. Please complete all questions honestly and as completely as you can. We need your answers to help us determine if speed limits for school buses should be changed or should remain the same.

Please return the questionnaire in the enclosed self addressed envelope to: Mr. Jack Jernigan, Research Scientist, Virginia Transportation Research Council, P.O. Box 3817, University Station, Charlottesville, Virginia 22903. We would like to have your response by June 5, 1989.

If you desire additional information or have questions concerning the study, please contact R. A. Bynum, Associate Director, Pupil Transportation Service at (804) 225-2037 or Jack Jernigan, Research Scientist, Virginia Transportation Research Council, at (804) 293-1909.

Enclosure

PUPIL TRANSPORTATION SURVEY

Bus Driver Questionnaire

May 1989

On the rural interstate highway system in Virginia, the maximum speed limit for school buses is 45 mph, but the maximum speed limit for trucks and other buses is 55 mph and that for passenger cars is 65 mph. On the urban interstate highways the speed limit for school buses is 45 mph and on other roads the maximum speed limit for school buses is 35 mph; however, school buses neither loading nor unloading passengers between the points of origin and destination have a maximum speed limit of 45 mph. We are interested in the impact these limits have on school bus safety. Please help us by filling out this questionnaire as completely as possible. **YOUR ANSWERS WILL BE HELD IN STRICTEST CONFIDENCE.**

1. Do you currently drive a regular route to and from school? (check one)

   yes _____ no _____

2. Do you feel that school buses can safely travel at 45 mph .....

   ON RURAL INTERSTATE ROADS? yes _____ no _____

   ON URBAN INTERSTATE ROADS? yes _____ no _____

   ON PRIMARY ROADS? yes _____ no _____

   ON SECONDARY ROADS? yes _____ no _____

3. Do you feel that school buses can safely travel at 55 mph .....

   ON RURAL INTERSTATE ROADS? yes _____ no _____

   ON URBAN INTERSTATE ROADS? yes _____ no _____

   ON PRIMARY ROADS? yes _____ no _____

   ON SECONDARY ROADS? yes _____ no _____

4. Do you feel that school buses can adequately go up hills at 45 mph?

yes _____ no _____

5. Do you feel that school buses can adequately go up hills at 55 mph?

yes _____ no _____

6. All school buses in Virginia are originally equipped with governors to limit the speed at which the bus can travel. What is the top speed that your bus can travel when the governor is in working order? (circle one)

35 40 45 50 55 60 65

7. As mentioned previously, on the rural interstate system, the maximum speed limit for passenger cars is 65 mph. The corresponding maximum speed limit for trucks is 55 mph, and the limit for school buses is 45 mph. What do you feel the maximum speed limit should be for school buses on the rural interstate system? (circle one)

35 40 45 50 55 60 65

Why do you feel this way?

_____

_____

_____

8. On urban interstates and other primary roads that have a 55 mph speed limit for passenger cars, what do you feel the maximum speed limit should be for school buses? (circle one)

35 40 45 50 55

Why do you feel this way?

_____

_____

_____

9. Do you feel the maximum speed limit for school buses should be different on regular routes than on special activity or field trips?

yes _____ no _____

Why do you feel this way?

_____

_____

_____

10. In your division, would it be possible to schedule school bus regular morning and afternoon routes on roads other than interstate highways? (check one)

yes _____ no _____

If yes, what alternative highways would you use?
If no, please state why this cannot be accomplished.

_____

_____

_____

11. In your division, would it be possible to schedule school bus special activity trips on roads other than interstate highways?

yes _____ no _____

If yes, what alternative highways would you use?
If no, please state why this cannot be accomplished.

_____

_____

_____

12. What factors do you feel should be considered in determining whether or not school buses should use interstate highways? Why?

_____

_____

_____

13. Would you support a prohibition of the use of school buses on interstate highways during regular morning and afternoon routes? (check one)

yes _____ no _____

Why do you feel this way?

_____

_____

_____

14. During the 1987/1988 school year, did you drive a school bus on special activity trips, such as field trips or sporting events? (check one)

yes _____ no _____ (if no, skip to question 16)

15. Please provide the following information (or an estimate, if necessary) concerning the special activity trips (field trips, sporting events) for which you drove a school bus during the 1987/1988 school year.

The total number of special activity trips (field trips, sporting events, etc.) for which you drove in 1987/88. _____

The average number of pupils transported on such trips. _____

The average number of miles traveled on such trips. _____

On such trips, the total mileage traveled on the interstate roads that now have a speed limit of 65 mph (for cars). _____

On such trips, the total mileage traveled on the interstate roads that still have a speed limit of 55 mph (for cars). _____

On such trips, the total mileage traveled on other non-interstate routes with a 55 mph speed limit. _____

16. Would you support a prohibition of the use of school buses on interstate highways during special activity trips? (check one)

yes _____ no _____

Why do you feel this way?

_____

_____

_____

17. Please describe the bus that you normally drove during the 1987/1988 school year.

Model Year _____

Chassis (Ford, Chevrolet, etc.) _____

Body (Thomas Built, Blue Bird, etc.) _____

Fuel Type (diesel/gas) _____

Capacity (32, 64, etc.) _____

Thank you for the time and effort you have taken to respond to these questions. Without your help, we would not be able to determine the impact that speed limit changes may have on school bus safety. Please put your response in the enclosed postage paid envelope and return it to us.

If you do not object to being contacted for further discussion of these issues, please complete the following:

Name _____ School Division _____

Address _____

_____

Phone No. ( ) _____

PLEASE RETURN TO:

Mr. Jack Jernigan
Research Scientist
Virginia Transportation Research Council
P. O. Box 3817, University Station
Charlottesville, Virginia 22903

COMMONWEALTH of VIRGINIA

DEPARTMENT OF EDUCATION
P.O. BOX 6Q
RICHMOND 23216-2060

MEMORANDUM

May 15, 1989

TO: Concerned Citizens and Organizations

FROM: R. A. Bynum RAB
Associate Director, Pupil Transportation Service

SUBJECT: Survey of School Bus Speed Limits

The Virginia Department of Education, in conjunction with the Virginia Transportation Research Council (VTRC), is conducting a study of optimal speed limits for school buses on Virginia highways. Currently, Virginia law limits school buses to a maximum of 35 mph on regular routes, and 45 mph on trips with no pickups or discharges and on the interstate highway system. Because other vehicles on the highways may have a speed limit up to 20 mph faster than that of school buses, the possibility of accidents being caused by vehicles traveling at very different speeds has caused some concern. Conversely, there is concern that school buses may not be able to travel safely at higher speeds.

The enclosed Opinion Questionnaire on School Bus Speed Limits contains questions that, when answered and returned, will provide the Department and VTRC with your opinions about the impact that multitiered speed limits have on school bus safety. Please complete all questions honestly and as completely as you can. We need your answers to help us determine if speed limits for school buses should be changed or should remain the same.

Please return the questionnaire in the enclosed self addressed envelope to: Mr. Jack Jernigan, Research Scientist, Virginia Transportation Research Council, P.O. Box 3817, University Station, Charlottesville, Virginia 22903. We would like to have your response by June 5, 1989.

If you desire additional information or have questions concerning the study, please contact R. A. Bynum, Associate Director, Pupil Transportation Service at (804) 225-2037 or Jack Jernigan, Research Scientist, Virginia Transportation Research Council, at (804) 293-1909.

Enclosure

PUPIL TRANSPORTATION SURVEY

Opinion Questionnaire

May 1989

On the rural interstate highway system in Virginia, the maximum speed limit for school buses is 45 mph, but the maximum speed limit for trucks and other buses is 55 mph and that for passenger cars is 65 mph. On the urban interstate highways the speed limit for school buses is 45 mph and on other roads the maximum speed limit for school buses is 35 mph; however, school buses neither loading nor unloading passengers between the points of origin and destination have a maximum speed limit of 45 mph. We are interested in the impact these limits have on school bus safety. Please help us by filling out this questionnaire as completely as possible. **YOUR ANSWERS WILL BE HELD IN STRICTEST CONFIDENCE.**

Name _____ Locality/Association _____

Title _____ Phone No. ( ) _____

1. On the rural interstate system the maximum speed limit for passenger cars is 65 mph. The corresponding maximum speed limit for trucks is 55 mph, and the limit for school buses is 45 mph. What do you feel should be the maximum speed limit for school buses on the rural interstate system? (circle one)

   35 40 45 50 55 60 65

Why do you feel this way?

_____

_____

_____

2. On urban interstates and other primary roads that have a 55 mph speed limit for passenger cars, what do you feel the maximum speed limit should be for school buses? (circle one)

   35 40 45 50 55

Why do you feel this way?

_____

_____

_____

3. Do you feel the maximum speed limit for school buses should be different on regular routes than on special activity or field trips?

Why do you feel this way?

_____

_____

_____

4. Would you support a prohibition of the use of school buses on interstate highways during special activity trips? (check one)

yes _____ no _____

Why do you feel this way?

_____

_____

_____

5. Are you involved in traffic law enforcement or do you represent a law enforcement agency?

yes _____ no _____ (please skip to question 7)

6. Do you feel that the current school bus speed limits are easy or difficult to enforce?

_____ easy to enforce

_____ difficult to enforce

Why do you feel this way?

_____

_____

_____

_____

7. Do you have any additional questions or comments concerning school bus speed limits?

Thank you for the time and effort you have taken to respond to these questions. Without your help, we would not be able to determine the impact that speed limit changes may have on school bus safety. Please put your response in the enclosed postage paid envelope and return it to:

Mr. Jack Jernigan
Research Scientist
Virginia Transportation Research Council
P.O. Box 3817, University Station
Charlottesville, Virginia 22903

APPENDIX F

Sample Size Calculations and Sampling Assumptions

Sample Size Calculation
Bus Driver Survey

$$n = \frac{(Z_{1-\alpha} + Z_{1-B})^2 (S^2)}{(M_1 - M_0)^2}$$

Where α, B are the levels of confidence and power, respectively [.05; .20]

$Z_{1-\alpha}$, Z_{1-B} are the normal curve values corresponding with α, B [1.96 + 0.85]

S^2 variance estimate

$M_1 - M_0$ the minimum detectable difference between the survey estimate of the mean and the true mean [10%]

Case 1:

Variance estimate based on maximum variance and minimum detectable difference for an 8-point speed scale:

$$\frac{(1.96 + 0.85)^2 (17.95)^2}{(3.5)^2} = 207.60$$

Case 2:

Variance estimate based on maximum variance and minimum detectable difference for a dichotomous question (yes/no):

$$\frac{(1.96 + 0.85)^2 (.50)^2}{(.10)^2} = 197.4$$

Sampling Assumptions:

Assumed Delivery Failure = 5%
Assumed Return Rate = 20%

APPENDIX G

Opinion Survey Tables

TABLE G-1

Preferred Rural Interstate Speed Limit for School Buses

Preferred Limit	Pupil Transp. Directors	Bus Drivers	Special Interest Groups
Less than 45 mph	___	7 (1.5)	___
45	36 (28.8)*	73 (15.3)	11 (14.1)
50	10 (8.0)	69 (14.5)	7 (9.0)
55	79 (63.2)	320 (67.2)	59 (75.6)
60 mph or more	___	7 (1.5)	1 (1.3)

*$\chi^2 = 14.76$; $p < .01$.

TABLE G-2

Preferred Urban Interstate Speed Limit for School Buses

Preferred Limit	Pupil Transp. Directors	Bus Drivers	Special Interest Groups
Less than 45 mph	3 (2.4)[b]	30 (6.3)	6 (7.8)
45	76 (61.3)	190 (40.0)	36 (46.7)
50	13 (10.5)	89 (18.7)	8 (10.4)
55	32 (25.8)	166 (35.0)	27 (35.1)
60 mph or more	___	___	___

[a]Preferred speed for urban interstate and primary roads.

[b]$\chi^2 = 14.70$; $p < .01$.

TABLE G-3

Safe Speeds for School Buses on Virginia's Highways

o Do you feel that school buses can travel safely at 45 mph on:

	Yes	No
Rural Interstate Road	341 (71.6)	135 (28.4)
Urban Interstate Road	342 (72.8)	128 (27.2)
Primary Roads	375 (79.3)	98 (20.7)
Secondary Roads	195 (41.3)	277 (58.7)

o Do you feel that school buses can travel safely at 55 mph on:

	Yes	No
Rural Interstate Roads	367 (77.1)	109 (22.9)
Urban Interstate Roads	313 (66.3)	159 (33.7)
Primary Roads	120 (25.4)	352 (74.6)
Secondary Roads	21 (4.5)	450 (95.5)

APPENDIX H

Accident Rates for Selected Interstate Highways and Parallel Primary Routes

1400

TABLE H-1

Accident Rates for Selected Interstate Highways and Parallel Primary Routes:

ACCIDENT RATE PER 100 MILLION VEHICLE MILES OF TRAVEL

		All Veh. Accident Rate				Truck Accident Rate			
		1986		1987		1986		1987	
County	Section	I-64	RT 250	I-64	RT 250	I-64	RT 250	I-64	RT 250
07	901	25	169	64	24	---	356	185	---
	901	25	136	64	245	---	---	185	358
	902	29	136	28	245	---	---	90	358
	903	9	136	---	245	---	---	---	358
	903	9	351	---	152	---	539	---	470
	904	19	351	103	152	---	539	51	470
	905	143	1420	---	450	1217	---	---	---
62	911	38	411	83	130	---	---	102	---
02	901	62	337	61	142	120	---	150	774
	901	62	268	61	340	120	---	150	---
	902	62	115	65	162	22	---	101	420
	902	62	156	65	147	22	---	101	---
	902	62	211	65	196	22	---	101	---
	903	48	211	66	196	40	---	267	---
	904	29	222	90	244	---	---	---	180
	905	101	222	69	244	234	---	---	180
	906	59	89	---	82	---	---	---	92
	908	73	89	54	82	---	---	130	92
	908	73	656	54	493	---	---	130	---
	909	33	299	52	275	67	---	---	798
	909	33	191	52	154	67	324	---	---
	909	33	330	52	212	67	---	---	---
	910	63	330	74	212	---	---	132	---
32	901	77	132	48	138	120	---	---	---
54	901	58	132	34	138	---	---	---	---
	902	46	163	83	114	61	---	81	---
	903	65	568	66	357	41	---	39	---
	903	65	---	66	---	41	---	39	---
37	905	35	---	99	---	---	---	---	---
	900	42	---	46	---	---	---	---	---
	900	42	118	46	97	---	---	---	---
	901	22	118	46	97	33	---	---	---

continues

TABLE H-1 (cont.)

Accident Rates for Selected Interstate Highways and Parallel Primary Routes:

ACCIDENT RATE PER 100 MILLION VEHICLE MILES OF TRAVEL

		All Veh. Accident Rate				Truck Accident Rate			
		1986		1987		1986		1987	
County	Section	I-64	RT 250	I-64	RT 250	I-64	RT 250	I-64	RT 250
54	904	25	118	48	97	---	---	---	---
	905	40	1055	91	338	---	---	184	---
	905	40	257	91	246	---	---	184	---
37	902	41	249	86	298	---	---	140	---
	903	40	249	54	298	63	---	39	---
	903	40	155	54	207	63	130	39	---
	904	20	155	83	207	---	130	153	---
43	901	61	412	19	295	57	---	---	---
	916	60	235	19	459	---	893	---	402
	902	50	194	50	293	144	260	47	---
	903	62	583	75	628	274	729	146	1151
	903	62	463	75	369	274	1290	146	377
	904	177	463	136	369	---	1290	326	377
	905	53	579	56	615	117	2151	306	475
	905	53	579	56	615	117	2151	306	475
	906	102	217	128	223	372	563	324	1502
	907	98	477	84	459	477	2009	84	2372
		I-64	RT 60	I-64	RT 60	I-64	RT 60	I-64	RT 60
43	910	108	368	100	342	---	---	742	---
	913	41	368	87	342	---	---	233	---
	913	41	694	87	578	---	161	233	430
	914	39	694	---	578	169	161	---	430
	915	28	178	36	165	24	---	75	---
	915	28	97	36	138	24	---	75	---
63	901	93	40	---	---	196	---	---	---
	902	36	80	48	184	142	115	67	202

Continues

TABLE H-1 (Cont.)

Accident Rates for Selected Interstate Highways and Parallel Primary Routes:

ACCIDENT RATE PER 100 MILLION VEHICLE MILES OF TRAVEL

		All Veh. Accident Rate				Truck Accident Rate			
		1986		1987		1986		1987	
County	Section	I-64	RT 60	I-64	RT 60	I-64	RT 60	I-64	RT 60
63	903	41	80	79	184	106	115	113	202
	904	47	60	37	124	102	139	98	225
	905	22	60	44	124	---	139	75	225
47	901	50	113	46	74	38	236	106	---
	902	20	113	27	74	71	236	63	---
	902	20	146	27	125	71	171	63	152
	903	45	146	34	125	54	171	49	152
99	904	38	302	78	211	81	---	74	---
89	910	86	262	44	226	206	331	97	254
	907	18	262	---	226	---	331	97	256
47	908	35	143	48	219	38	---	35	---
	909	109	143	98	219	261	---	245	---
	900	26	---	24	113	89	---	---	148

		1986		1987		1986		1987	
County	Section	I-81	RT 11	I-81	RT 11	I-81	RT 11	I-81	RT 11
95	905	74	113	35	113	105	---	83	148
	906	58	113	51	113	130	---	67	148
	907	57	113	68	113	81	---	194	148
	908	59	305	44	293	48	1025	110	---
	908	59	266	44	384	48	---	110	---
	908	59	235	44	55	48	1115	110	---
	909	61	151	27	202	144	---	45	---
	910	67	130	70	216	51	---	94	---
	910	67	130	70	216	51	---	94	---
	911	96	163	31	256	128	---	85	---
	912	30	163	68	256	20	---	78	---
	913	49	82	41	78	64	---	66	---
	914	14	82	84	78	25	---	138	---

continues

TABLE H-1 (Cont.)

Accident Rates for Selected Interstate Highways and Parallel Primary Routes:

ACCIDENT RATE PER 100 MILLION VEHICLE MILES OF TRAVEL

		All Veh. Accident Rate				Truck Accident Rate			
		1986		1987		1986		1987	
County	Section	I-81	RT 11	I-81	RT 11	I-81	RT 11	I-81	RT 11
86	901	26	178	64	337	46	---	---	---
	902	24	173	22	407	14	---	---	---
	902	24	59	22	82	14	---	---	---
	903	24	270	29	99	28	---	25	---
	904	23	139	---	219	---	---	---	1134
	905	---	---	93	---	---	---	206	---
	912	57	208	55	410	210	---	204	---
	908	32	208	31	410	39	---	37	---
	909	47	208	58	410	68	---	47	---
	910	15	179	48	155	23	---	63	---
98	901	24	70	56	267	---	---	17	---
	902	49	121	33	193	59	235	47	---
	903	75	---	31	---	149	---	18	---
	907	19	56	33	16	22	58	32	57
	911	43	56	20	16	31	58	---	57
77	901	43	171	49	---	62	---	42	---
	901	43	244	49	115	62	---	42	---
	902	62	244	37	115	54	---	36	---
	902	62	154	37	149	54	669	36	---
	903	66	154	95	149	23	669	23	---
	904	32	85	58	564	50	---	47	---
	904	32	377	58	427	50	---	47	---
	905	48	71	39	81	54	---	35	---
	906	34	232	32	192	46	---	22	---
	906	34	620	32	444	46	3374	22	---
	906	34	507	32	685	46	---	22	---
	901	---	---	---	40	---	---	---	---
60	901	115	106	35	85	229	---	---	---
	902	57	106	90	85	78	---	128	---
	903	49	106	49	85	62	---	57	---

continues

TABLE H-1

Accident Rates for Selected Interstate Highways and Parallel Primary Routes:

ACCIDENT RATE PER 100 MILLION VEHICLE MILES OF TRAVEL

		All Veh. Accident Rate				Truck Accident Rate			
		1986		1987		1986		1987	
County	Section	I-81	RT 11	I-81	RT 11	I-81	RT 11	I-81	RT 11
60	903	49	189	49	114	62	84	57	133
	907	35	189	66	114	61	84	109	133
	908	50	102	96	161	37	79	105	250
80	901	37	264	54	288	22	545	82	217
	902	35	164	53	133	68	---	63	---
	903	58	483	62	448	84	---	91	---
	904	55	315	51	234	68	136	58	---
11	901	81	115	96	159	191	80	108	299
	901	81	595	96	351	191	938	108	480
	902	80	145	69	551	40	---	94	686
	902	80	126	69	171	40	---	94	411
	902	80	224	69	80	40	---	94	---
	903	57	238	51	308	61	---	84	217
	904	69	238	54	308	101	---	59	217
	904	69	194	54	144	101	393	59	237
	904	69	400	54	477	101	---	59	---
	905	90	---	135	657	117	---	110	---
	906	37	---	26	---	8	---	8	---
81	901	44	117	61	92	108	---	65	---
	902	46	116	58	142	18	817	44	---
	903	42	173	61	162	10	---	76	---
	904	55	158	67	100	89	---	92	---
	904	55	667	67	430	89	---	92	---
	904	55	132	67	205	89	---	92	---
	912	43	171	32	113	11	---	34	318
	905	63	159	66	176	83	329	89	578
	905	63	130	66	64	83	---	89	205
	907	67	130	82	64	66	---	129	205
	906	58	130	55	64	187	---	88	205
07	901	33	136	41	128	38	---	32	142
	902	20	138	38	130	27	116	49	183
	903	31	138	32	130	44	116	40	183
	907	95	138	38	130	107	116	---	183
	908	54	161	55	105	95	---	75	---
	904	36	178	45	188	42	---	39	---
	905	39	178	58	122	53	---	69	343
	906	29	127	54	181	26	---	93	---

continues

TABLE H-1

Accident Rates for Selected Interstate Highways and Parallel Primary Routes:

ACCIDENT RATE PER 100 MILLION VEHICLE MILES OF TRAVEL

		All Veh. Accident Rate				Truck Accident Rate			
		1986		1987		1986		1987	
County	Section	I-81	RT 11	I-81	RT 11	I-81	RT 11	I-81	RT 11
82	901	51	78	36	132	28	---	62	---
	902	25	172	23	83	36	741	33	---
	903	25	216	23	140	36	---	33	240
	905	28	216	43	140	20	---	19	240
	906	41	132	37	155	49	---	32	385
	906	41	257	37	283	49	---	32	162
	907	47	106	42	108	71	---	44	---
85	901	17	311	16	396	52	---	---	---
	914	---	311	---	396	---	---	---	---
	915	67	163	44	463	---	---	121	---
	915	67	718	44	217	---	---	121	---
	902	38	141	38	213	41	---	39	1274
	902	38	98	38	89	41	---	39	---
	903	40	98	40	89	41	---	30	---
	903	---	---	---	228	41	---	30	---
	903	40	210	40	539	41	---	30	630
	904	33	77	31	62	35	---	11	144
	905	27	77	25	62	---	---	---	144
	906	31	259	43	98	26	---	37	---
	906	31	75	43	124	26	---	37	---
	907	29	75	85	124	87	---	81	---
	908	87	427	46	202	37	---	---	---
	910	73	806	44	866	68	---	44	360
	910	73	118	44	139	68	---	44	---
	911	30	187	31	59	27	---	25	---
	911	30	179	31	155	27	---	25	6715
	911	30	551	31	1234	27	---	25	---
	911	30	1113	31	670	27	---	25	---
	912	54	186	52	203	53	---	74	---
	912	54	196	52	204	53	527	74	---
	913	224	196	21	204	201	527	62	---
93	901	108	265	91	---	---	---	---	---
34	901	0	71	---	77	---	---	---	---
	902	8	71	50	77	---	---	---	---
	902	34	190	50	286	111	---	47	---
	903	34	129	50	---	111	---	47	---
	903	34	111	50	72	111	---	47	72

continues

TABLE H-1 (Cont.)

Accident Rates for Selected Interstate Highways and Parallel Primary Routes:

ACCIDENT RATE PER 100 MILLION VEHICLE MILES OF TRAVEL

		All Veh. Accident Rate				Truck Accident Rate			
		1986		1987		1986		1987	
County	Section	I-81	RT 11	I-81	RT 11	I-81	RT 11	I-81	RT 11
34	915	58	111	---	72	---	---	---	72
	904	33	145	27	---	---	---	29	---
	904	33	207	27	375	---	---	29	424
	904	33	64	27	72	---	---	29	---
36	905	47	64	32	72	74	---	63	---
	905	47	143	32	120	74	---	63	---
	905	47	206	32	202	74	298	63	---
	906	11	125	31	238	21	442	40	326
	907	79	125	32	238	126	442	16	326
	908	55	144	37	114	70	---	67	---
	909	21	144	19	114	16	---	16	---
	910	37	144	---	114	---	---	---	---

		1986		1987		1986		1987	
County	Section	I-85	RT 1	I-85	RT 1	I-85	RT 1	I-85	RT 1
58	901	67	119	60	135	43	---	61	---
	902	35	119	26	135	10	---	11	---
	902	35	101	26	151	---	---	11	154
	903	52	133	66	---	---	---	---	---
	906	72	99	61	144	50	---	---	229
12	901	99	139	73	90	42	116	39	107
	902	68	139	46	90	36	116	---	107
	903	48	139	22	90	89	116	---	107
	903	48	141	22	343	89	---	---	373
	904	95	1047	69	---	82	---	75	---
	904	95	---	69	236	82	---	75	---
	904	95	249	69	---	82	---	75	---
	904	95	217	69	146	82	---	75	---
	905	44	217	68	146	21	---	39	---
	906	80	217	75	146	167	---	---	---
	906	80	---	75	1079	167	---	---	---
26	900	65	185	61	---	77	---	---	---
	901	71	---	39	---	15	---	---	---

continues

TABLE H-1 (Cont.)

Accident Rates for Selected Interstate Highways and Parallel Primary Routes:

ACCIDENT RATE PER 100 MILLION VEHICLE MILES OF TRAVEL

		All Veh. Accident Rates				Truck Accident Rates			
		1986		1987		1986		1987	
County	Section	I-85	RT 1	I-85	RT 1	I-85	RT 1	I-85	RT 1
26	901	71	470	39	224	15	---	---	---
	901	71	72	39	99	15	---	---	139
	902	68	72	81	99	71	---	98	139
	903	35	98	48	106	47	109	67	90
	904	102	98	39	106	71	109	64	90
	904	102	263	39	218	71	---	64	---
	907	128	111	39	63	191	---	64	---
	905	237	89	44	128	532	---	91	---

		1986		1987		1986		1987	
County	Section	I-95	RT 1	I-95	RT 1	I-95	RT 1	I-95	RT 1
20	903	38	238	36	235	---	81	---	520
	904	66	238	66	235	---	81	---	520
	905	95	350	92	340	---	110	---	555
	906	103	366	111	345	---	649	---	309
	906	103	273	111	220	---	207	---	595
	907	79	345	146	272	---	442	---	141
43	926	60	73	73	184	---	---	197	795
	927	---	73	56	184	---	---	---	795
	928	79	366	73	378	---	357	91	638
	929	87	366	50	378	221	357	94	638
	929	17	540	50	721	221	1499	94	---
	930	19	307	27	282	32	---	76	582
	931	42	120	49	166	97	---	43	517
42	901	218	280	37	139	725	60	---	453
	902	51	280	48	139	121	60	63	453
	903	78	280	30	139	148	60	44	453
	903	78	62	30	106	148	---	44	325
	904	27	62	46	106	41	---	82	325
	904	27	181	46	122	41	---	82	291
	904	27	138	46	172	41	---	82	530
	905	28	138	39	172	54	---	65	530

continues

TABLE H-1 (Cont.)

Accident Rates for Selected Interstate Highways and Parallel Primary Routes:

ACCIDENT RATE PER 100 MILLION VEHICLE MILES OF TRAVEL

		All Veh. Accident Rate				Truck Accident Rate			
		1986		1987		1986		1987	
County	Section	I-95	RT 1	I-95	RT 1	I-95	RT 1	I-95	RT 1
16	901	52	62	37	157	35	---	55	359
	902	39	186	53	146	48	---	104	---
	903	39	186	50	146	36	---	45	---
88	901	66	330	51	228	36	---	69	266
	902	106	215	73	159	133	---	95	172
	903	91	723	52	697	181	1064	80	581
	903	91	697	52	489	181	253	80	1456
	905	72	454	66	518	79	926	---	443
89	901	68	192	71	380	95	---	166	639
	901	68	180	71	121	95	---	166	65
	902	82	180	70	121	125	---	95	65
	903	68	255	41	274	123	---	45	165
	904	61	139	55	158	108	69	74	144
76	920	108	358	74	287	165	---	---	141
	921	77	358	69	287	79	---	67	141
	922	70	358	66	287	130	---	137	141
	922	70	893	66	733	130	386	137	412
	923	118	512	94	393	230	250	119	644
	924	103	512	116	393	98	250	204	644
	926	101	512	97	393	140	250	204	644
	925	248	630	318	551	270	---	228	1482
29	920	188	216	227	206	286	176	311	1522
	921	162	318	211	391	385	95	432	1128
	922	165	466	173	472	421	---	410	574
	923	202	466	203	472	593	---	474	574
	923	202	326	203	304	593	---	474	449
	924	529	752	567	727	1840	77	1070	767
	950	109	752	146	727	429	77	425	767
	951	45	722	57	558	220	2283	113	1009
	954	65	707	103	589	412	1287	347	846