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September 10, 1980

MEMORANDUM

TO : Mr. Wayne S. Ferguson

FROM : Christopher R. Pastel and Cheryl Lynn

SUBJECT: Speed Limits for Overwidth Vehicles on Virginia Highways, VHTRC 81-R17

This memorandum examines the data collected during the Research Council's 1976 study of the transportation of 12- and 14-foot wide manufactured housing units to determine whether the data were adequate for analyzing the effects of wide load speeds on other traffic and, if possible, to determine what these effects were. The major conclusion from the examination of the data is that the wide load vehicles traveling above 45 mph on interstate and four-lane divided highways had lower accident potentials than did those traveling at slower speeds. Accordingly, it is recommended that the speed limit on interstate and four-lane divided highways for overwidth manufactured housing units be changed to 55 mph, the speed which would put these vehicles in reasonable conformity with other traffic.

BACKGROUND

In 1976 the Virginia Highway and Transportation Research Council conducted a study in response to House Joint Resolution No. 41 which requested that the Department of Highways and Transportation evaluate the movement of 14-foot wide mobile and modular housing units over the highways of the Commonwealth. (1) *The Housing Study Commission, the Office of Housing, the Highway Safety Division (later named the Department of Transportation Safety), the Department of State Police, representatives from the manufactured housing industry, and the Division of Motor Vehicles were asked by the Resolution to assist in the study. At the time of the Resolution, Virginia was one of only seven states which did not allow 14-foot wide mobile or modular housing units on their highways. The 1976 study compared the effects on traffic of 12-foot wide units with the effects of 14-foot wide units. During an 8-week period, traffic and safety data were collected on 3,782 miles of Virginia highways by a five-man crew using photographic and manual techniques. The study determined that the 14-foot units had essentially the same effects on traffic as the 12-foot wide units. The Department of Highways and Transportation subsequently began issuing permits allowing 14-foot wide units on Virginia highways.*

One of the peripheral findings of the 1976 study stated that "a preliminary analysis of speed, volume, impedance, and conflict data suggested that the safety and convenience of the motoring public could be enhanced if the wide load speed was close to the mean speed of the traffic stream." (2) The evaluation did not specifically address the question of speed limits since it was felt that to do so would have exceeded the authorized scope of the study. After the report on the study was published, however, representatives of the manufactured housing industry approached officials of the Department of Highways and Transportation to see if an additional study could be made of the effects on traffic of the present speed limit for overwidth housing units. The Department agreed to have the Research Council examine the data collected in the 1976 study to determine if any conclusions could be drawn concerning speed limits for overwidth housing units.

PURPOSE AND SCOPE

The purpose of this investigation was to determine if the data collected for the 1976 study were adequate for analyzing the effects of the speeds of wide loads on surrounding traffic, and if they were found to be adequate, to determine what effects were evident from a safety point of view. Specifically, this study tested four hypotheses: (1) that increasing the speed limit for wide loads would have no effects on traffic conflicts, (2) that this action would increase such conflicts, (3) that it would reduce conflicts, and (4) that traffic impedance would be changed by increasing the speed limit for wide loads. It was assumed that a reduction in delays of traffic and an increase in the convenience of the motoring public would result if traffic impedance were reduced and that traffic safety would be increased if conflicts were reduced. This study was not designed to determine the "best" speed in an absolute sense; it was designed solely to test the finding of the 1976 study suggesting a connection between the speed of wide loads and the safety and convenience of the motoring public.

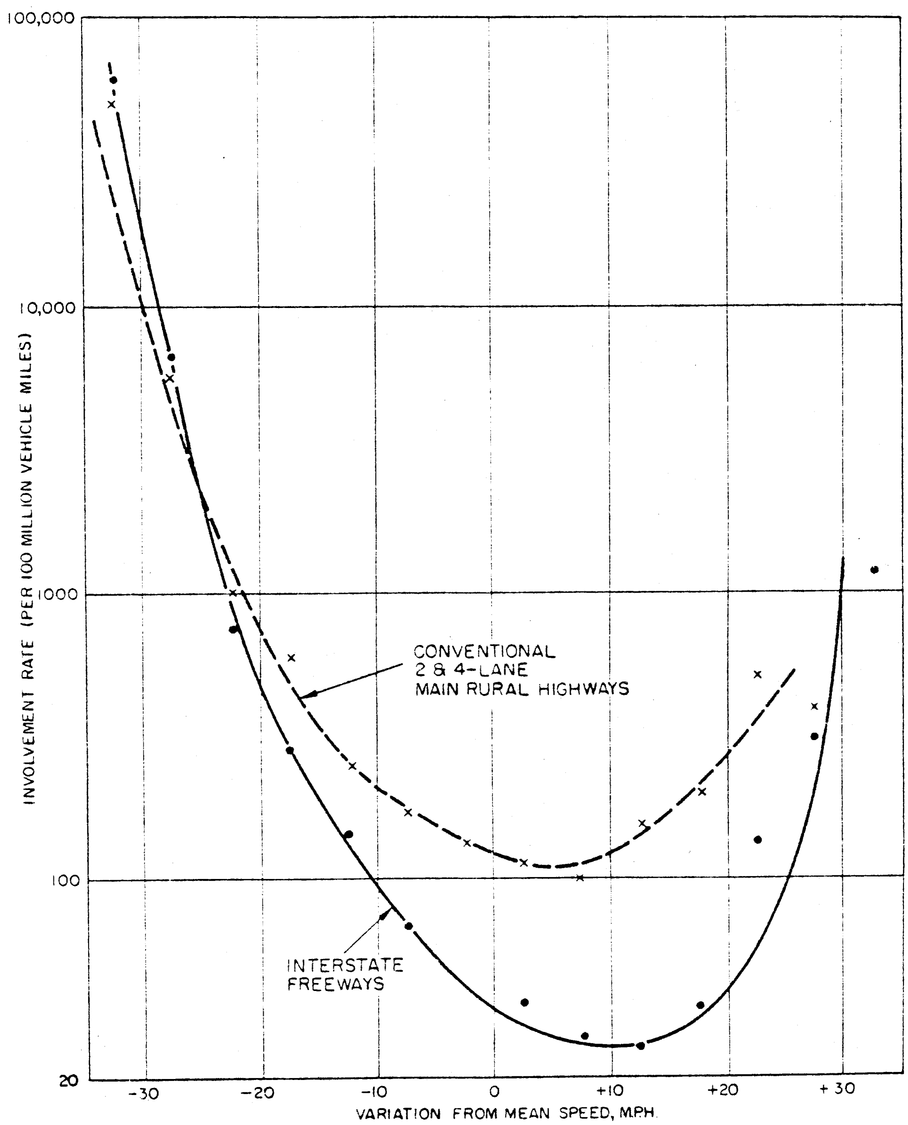
One specific limitation of the data from the 1976 study should be mentioned here. The original study was not designed to test the wide load speed hypotheses, i.e., the speed of the wide load vehicles was not controlled as an independent variable. Some problems which arose thereby in the analysis were the limited sample size and the small variance observed. In addition, the ranges of speeds on the different types of highway were not as broad as desired for the present analysis. However, the use of statistical methods permitted several conclusions to be drawn from the 1976 study data.

LITERATURE REVIEW

A review of the literature was conducted to examine the effects of the speed of wide load vehicles on surrounding traffic. The review was initiated through the services of the Highway Research Information Service. Research Council files, Virginia General Assembly Reports, and Virginia Legislative Services files were also examined. Only one study was found conerning the speed of wide loads in addition to the Council's 1976 study. However, it was felt that other than their width, wide loads were similar to tractor-trailers. The tractors which pull ordinary trailers and wide load tractors are identical, and the braking requirements for tractor-trailers and wide load vehicles are the same. (3) Therefore, studies pertaining to the effects of trucks and tractor-trailers were also examined because of the lack of wide load studies.

The first national study that showed a relationship between speed distribution and accident rates was reported by David Solomon in 1964.[4] Data were collected on 35 sections of highway around the country, 8 of which were four-lane roads. Variables examined included traffic characteristics (volume, day vs. night, mean speed of traffic, type of highway), driver characteristics (age, sex, residence, military status), vehicle characteristics (body style, age of car, horsepower, price, size, type of vehicle), and accident characteristics (fatalities, injuries, property damage, type of collision, number of vehicles per accident, speed of vehicles involved in accidents). The basic finding of the study was that the accident involvement rate was lowest at about the average speed of all traffic and highest at very low and very high speeds. This was true for trucks as well as cars. Figure 1 shows the involvement rate by travel speed for day and night.

FIGURE 1



Source: David Solomon, "Highway Safety Myths," presented at the Symposium on Highway Safety, University of North Carolina, Highway Safety Research Center, Raleigh, North Carolina, Spring 1970.

Other studies have confirmed the speed distribution-accident rate relationship. One of the most thorough studies was published in 1970 by the Research Triangle Institute. (5) *All state highways and county roads in Monroe County, Indiana, with a speed limit of 40 mph or more were included in the study; however, all were two-lane roads. Over 200 accident investigations covering 70 miles of road were completed during a 13-month period. The major conclusion of the study was that the likelihood of being involved in an accident increased by a factor of 10 if one were traveling 16 mph above or below the mean speed of the traffic. All types of vehicles were included in the scope of the study; truck accident data were not analyzed separately.*

A study conducted by the University of Maryland in 1974 dealt specifically with the effects of imposing a speed limit differential between cars and trucks. (6) *Vehicular speed and accident data were collected and analyzed for 84 study sites located on interstate, U. S., and state routes throughout Maryland. The study tested the following premise for establishing differential speed limits for trucks: since a truck requires longer to decelerate from a given speed than a car, highway safety is best served when the braking distances for cars and trucks are compatible. Over 97% of the truck speeds observed were less than 70 mph. Two major conclusions of the study were that (1) trucks were not complying with the posted speed limit differential, and (2) higher truck speeds were assocaited with lower accident rates. The study recommended thattruck speeds be raised to 70 mph (the same as for passenger cars at that time) on selected portions of interstate highways to test the hypothesis that the lower accident rate for trucks at higher speeds was due to the reduced speed differential. However, the national 55 mph speed limit was imposed before the recommendation could be implemented.*

In 1976 a study performed by Purdue University's Joint Highway Research Project Engineering Experiment Station examined the characteristics of heavy truck accidents both before and after the imposition of the national 55 mph speed limit; i.e., when a truck speed limit differential was in effect and when it was not. (7) *Twenty-four interstate, 26 other four-lane, and 75 two-lane rural highway sections, each about 20 kilometers (12 miles) long, were used. Accident data for each section were provided by the Indiana State Police. Table 1 contains the average heavy truck accident rates and the posted and actual speed differentials before and after the national 55 mph speed limit came into effect. Accident rates for heavy trucks decreased significantly on interstate and four-lane highways. The decrease on two-lane highways was not statistically significant. The study concluded that "reductions in the average heavy truck accident rate after the 55 mph maximum speed limit is probably primarily due to the lesser variability in speed differences between passenger cars and trucks with possibly some effect of reduced speeds by both types of vehicles."*

Then, in 1974, a study was performed solely on one particular type of wide load vehicle. The Midwest Research Institute published a study in 1974 evaluating the economics of shipping mobile and modular units by highway. (8) *Sixty-two trips covering around 12,000 miles of highway in 18 states were made with 12-foot and 14-foot wide units. Thirty-nine of the trips were on multi-lane highways. Photographic coverage of the trips was used to obtain speed-distance profiles with the aid of computer processing techniques. Data were also obtained by observers traveling with the wide load. The study found that "slower moving wide loads created more problems and more impositions on other motorists than did faster moving loads, regardless of the width of the load," and that "slow moving wide loads create more traffic impedances and initiate driver responses of a more hazardous nature than do faster moving wide loads." The study also found that costs due to delay in vehicle operations borne by other drivers increased significantly on multilane highways as the speed of the wide load decreased.*

TABLE 1

EFFECTS OF THE NATIONAL 55 MPH SPEED LIMIT ON HEAVY TRUCK ACCIDENT RATES, TRUCK-CAR SPEED DIFFERENTIALS, AND TRUCK-CAR POSTED SPEED LIMIT DIFFERENTIALS

	Interstate		Other Four-Lane		Two-Lane	
	Pre-55	Post-55	Pre-55	Post-55	Pre-55	Post-55
Average heavy truck accidents per million vehicle miles of travel	78.04	54.68	198.89	148.81	167.28	141.37
Actual average speed differential in mph	10	2	9	3	6	2
Posted speed limit differential in mph	15	0	10	0	15	0

The study recommended that the speed limits for wide loads be not less than 45 mph on two-lane roads and at least 50 mph on multi-lane highways.

The studies reviewed above indicated that speed differentials were related to accident rates for cars, trucks, and wide loads. Thus, imposing speed limit differentials for different types of vehicles may increase accident rates. As discussed later in this memorandum, the data from the 1976 Research Council study suggest that the speed limit differentials imposed on wide loads in Virginia may also adversely affect accident rates.

LEGISLATIVE HISTORY

The present Virginia Code section 46.1-193(1)(e) establishes a maximum speed limit of 45 mph for all vehicles operating under a special permit issued by the Department of Highways and Transportation. The special permit is required for vehicles (including loads) which exceed a specified weight, length, or width. The specified maximum width is 8 feet; so any manufactured housing units which are more than 8 feet wide ("wide load" vehicles) require a permit and are subject to the 45 mph speed limit. (9) Vehicles operating under a special permit were first assigned a maximum speed, in 1952, of 30 mph. This maximum speed was raised to 45 mph in 1956 and has not been changed since then. No reports or studies were found in Research Council files, Virginia General Asssembly Reports, or in Virginia Legislative Services files which explained or justified the speed limit for special permit vehicles.

The Uniform Vehicle Code (UVC) does not set a speed limit for vehicles requiring a special permit. Section 14-112(a) states that "the (State Highway Commission) is authorized . . . to limit or prescribe conditions of operation of such vehicle or vehicles when necessary to protect the safety of highway users, or to protect the efficient movement of traffic from unreasonable interference." The UVC thus leaves the regulation of the speed of vehicles requiring a permit to the highway department of each state.

The states surrounding Virginia follow the UVC's approach. Each one authorizes the state highway department to regulate the speed limit for vehicles requiring a permit rather than establishing a speed limit by statute. Tennessee and Maryland do not set a lower speed limit for wide loads than for normal traffic. Kentucky limits the speed of only 14-foot wide house trailers (45 mph on interstate highways and 35 mph on all other highways); other wide loads are subject to the normal speed limit. West Virginia limits all over width mobile homes (but no other oversize loads) to 40 mph on all types of highway. North Carolina also limits only over width mobile homes; the limit is 45 mph for four-lane highways. The only common factor among those states which impose a lower speed limit for vehicles operating under a permit is a belief that mobile homes/house trailers create hazards for traffic if permitted to travel in excess of 45 mph.

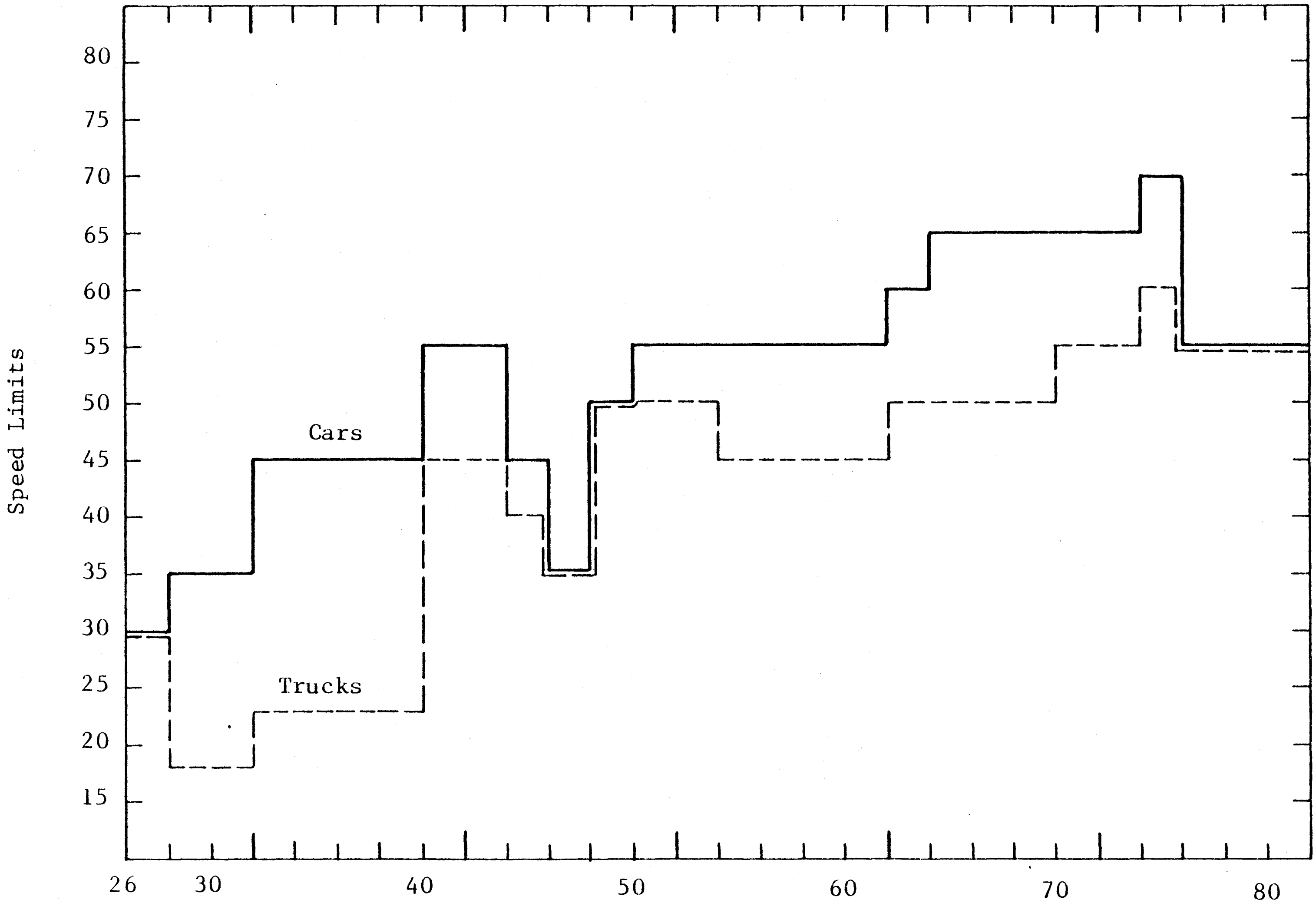
An examination of the history of speed limits for trucks is useful at this point. As mentioned earlier, other than their width, wide load vehicles are similar to trucks. The speed limit differential between cars and trucks has ranged from a high of 17.5 mph to a low of 0 mph in 1974. At times, the differentials seem to have been imposed arbitrarily. See Figure 2 for a comparison of truck speed limits with car speed limits.

In 1924 the "normal" speed limit for all vehicles was 30 mph on open roads, and the motorist was required to slow down to 10 mph when approaching a gathering of horses or people. Vehicles carrying more than severn people were limited to a top speed of 20 mph. The Motor Vehicle Act of 1926 established speed limits for business districts (15 mph), residential districts (25 mph), and "under all other conditions" (35 mph). Motor trucks were given different speed limits: a truck with pneumatic tires and weighing less than 1 1/2 tons could travel the same speed as cars; trucks without penumatic tires and trucks weighing between 1 1/2 and 3 1/2 tons could travel at two-thirds the speed of cars; and finally, trucks weighing more than 3 1/2 tons were limited to one-half the speed of cars.

This was the first differential speed limit for trucks in Virginia, and it was probably attributable to the vehicle characteristics of the early trucks. At that time, trucks were predominately car bodies with truck beds attached. When loaded, these trucks would have different handling and braking characteristics than automobiles. Modern trucks, however, are designed as separate types of vehicles and their performance and safety characteristics enable them to mix safely with automobiles and other vehicles on today's highways. Speed differentials for different types of vehicles may have been justified in the past, but the original reasons for the differentials are no longer apparent.

Speed limits were slowly raised throughout the years. Increases came in 1930 and 1938. In 1938 the speed limit for trucks was set at 45 mph and that for cars at 55 mph. In 1942, the limits were reduced to 45 mph for cars and 40 mph for trucks in order to conserve tires and fuel for the war effort. A further reduction came in 1944 when a limit of 35 mph was established for all types of vehicles. No rationale for abolishing the differential was given; one suspects it was because lowering truck speed limits below 35 mph could not be economically justified. When the limits were raised in 1946, all vehicles except school buses were allowed a top speed of 50 mph. While a differential limit was evidently considered unnecessary, there are no studies or reports which state why that should have been so. Differential speed limits again appeared in 1948 when passenger buses, motorcycles, and cars were permitted to travel at 55 mph on four-lane divided highways. For some reason, trucks were still limited to 50 mph. Again, one suspects this was because of the physical characteristics of trucks; what is thought of as the "modern truck" first appeared in the late 1950's.

Figure 2



Passenger Car and Truck Speeds, 1926 to 1980

In 1960 trucks were allowed to travel at 50 mph on four-lane divided highways if an engineering and traffic investigation had been completed, and cars were permitted to go 60 mph. In 1962, the speed differential was raised to 15 mph, when cars were permitted to travel at 65 mph on interstate or other four-lane divided limited access highways. This increase in speed limits for cars was made in recognition of the design standards incorporated in the recently opened interstate highways in the state. The differential dropped to 10 mph in 1958 when trucks were allowed to go 55 mph on interstate highways.

Of the 43 states surveyed in a 1968 study, 22 had no differential for trucks on interstate highways. (10) *The changes after 1968 were brought about by raising the speed limits for cars while leaving the speed limits for trucks unchanged. Several items contributed to the increasing speeds: the desire to reduce travel time, improvement in road construction and design, and the automotive industry's improved technology.* (11) *According to one state official, the speed limit for trucks was raised in 1968 because of the increased number of trucks on the highways and the perceived traffic impedance and inconvenience to motorists of having trucks traveling at lower speeds than the rest of the traffic.* Truck speeds lagged behind automobile speeds, however, in part because trucks were perceived as "huge, monstrous gas-gulping highway-consuming murderous vehicles."* (12) *By the time of the energy crisis in 1973, differentials were again as great as 15 mph in more than a few states.* (11)

Virginia Executive Order 36 of November 26, 1973, lowered the maximum speed to 55 mph in response to the President's request for lower speed limits. This reduced speed limit was incorporated in the Virginia Code in 1977 and is in effect today. The current speed limits are 55 mph on interstate, four-lane divided, and all state primary highways for both cars and trucks. Trucks are restricted to 45 mph on all other highways, i.e., state secondary roads and local roads. School buses and vehicles operating under a special permit have a speed limit lower than cars on all highways. (14)

Just how dangerous the speed differentials were was not realized until the national maximum 55 mph speed limit was imposed in 1974. Studies done before and after the onset of the energy crisis showed that reducing the speed differentials of all traffic contributed significantly towards reducing the number of traffic accidents. (4-8, 14-17)

The legislative history of speed laws in Virginia compels this conclusion: For years, speed limits for different types of vehicles have been set based on "intuition" or "belief" instead of on traffic studies. The studies reviewed previously suggest that imposing unnecessary speed differentials on wide load vehicles is generally unsafe and uneconomical. The present study attempts to determine from empirical data if this is the case for wide load vehicles on Virginia highways.

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* *Personal communication: Robert DuVal, Deputy Director of the Virginia Department of Transportation Safety, June 5, 1980.*

METHOD

Data Analyzed

In testing the hypothesis that increasing the speed limit for wide loads would either have no effect on traffic conflicts or would reduce them, the present study used elements of the data collected by the Research Council in its 1976 study of the movement of wide loads. Specifically, the data used were (1) type of highway, (2) running time, (3) trip length, (4) conflicts, (5) impedance, (6) volume in the same direction, and (7) volume in the opposing direction. The highway types involved in the 1976 study were interstate, four-lane divided, two-lane primary, and secondary. Of the 162 valid trips, 17% were on interstate highways, 32% on four-lane divided highways, 36% on two-lane primary highways, and 15% on secondary roads. About 32% of the total mileage was on interstate highways, 45% on four-lane divided highways, 19% on two-lane primary highways, and 3% on secondary roads. The average speed for each trip was calculated from the running time and trip length. The number of conflicts per trip was recorded, with a conflict being defined as any potential accident situation. [18] Conceptually, a driver avoids an accident by taking evasive action, usually either by braking or by changing lanes; so conflicts were counted by observing brake applications, as evidenced by the brake lights, and lane changes. The total impedance for each trip was also measured. Impedance was defined as the length of time (in seconds) that a vehicle was in queue behind the wide load. Total impedance per trip was the sum of all vehicle impedances during the journey. Conflicts and impedance have been used instead of accident rates to evaluate highway safety and operational efficiency. [1,18] Accidents are so infrequent that it is hard to gather enough data in a reasonable period of time to enable statistical analysis. In addition, there were no wide load accidents during the 1976 study, and the state accident reporting form (FR-300) did not separate wide load vehicle accidents from truck accidents. The concepts of traffic conflicts and traffic impedance were developed to permit statistical analysis in the absence of data on accident rates.

In relation to "traffic volume in the same direction," a count of one was recorded each time a vehicle approached the wide load from behind and each time the wide load approached another vehicle traveling in the same direction. Since this count was made by an observer moving with the load, the count theoretically would be zero if the wide load were moving at the same speed as other vehicles in the traffic stream. Therefore, this definition of volume is one measure of speed differential between the wide load and the other traffic.

Traffic volune in the opposite direction was counted on two-lane highways only, since it was only on two-lane highways that the traffic coming from the opposite direction had any interactions with or effects on the wide load. Both measures of traffic volume (same direction and opposing direction) were normalized to correct for unequal trip lengths, with the result being expressed as vehicles per mile. For two-lane highways the total volume was computed by adding the same direction volume to the opposing direction volume. Since the opposing volume is not related to the speed differential between the wide load and the rest of the traffic stream, the total volume was not considered in this study.

Data for 12-foot wide loads and 14-foot wide loads were combined for analysis since (1) the present study was examining the effects of all wide loads, and (2) the 1976 study found no major differences between the traffic and safety characteristics of the two types of wide loads.

Analyses Performed

Several statistical techniques were used to analyze the data. Analysis of variance (ANOVA) was used to determine the effect of different speed levels on conflicts and impedance. Pearson correlation coefficients were computed between all combinations of speed, conflicts, impedance, and volume to see if there were any relationships between the variables. Partial correlation coefficients were also computed between selected variables to determine if the relationships discovered by using the Pearson correlation techniques were attributable to only one variable (such as speed) or to an interaction of several variables.

RESULTS

The hypothesis tested was that traffic conflicts and impedance would decrease as the speeds of wide load vehicles increased. If it was found that conflicts and impedances increased as the speeds increased, then a need for lowering speed limits would be indicated. If it was found that conflicts and impedances were not affected by speeds, then there would be no safety effects of lowering or raising the speed limits for wide load vehicles. If there were no effects on safety, then it might be desirable to raise speed limits for wide load vehicles because of the economic advantages of being able to move wide loads in less time.

The data were tested to see if the impedance and conflict levels were different at various levels of speed and volume. The data for interstate and four-lane divided highways were examined together and then separately because the manufactured housing industry was specifically concerned with raising the speed limits for wide loads on these highways. The data for two-lane highways were examined to provide a comparison with the results for four-lane highways.

Interstate and Four-Lane Divided Highways

Of the 80 trips on interstate and four-lane divided highways, 44 had average running speeds lower than 45 mph and 36 had average running speeds greater than 45 mph. This selection of speed categories was made since the legal speed limit for wide loads in Virginia is 45 mph. The traffic volume was categorized as low, medium, or high in such a way that approximately one-third of the trips fell in each category.

The mean conflicts and impedance for each category of speed and traffic volume were determined and the results appear in Table 2. The conflict levels for the "below 45 mph" speed category appear greater than those for the "above 45 mph" speed category and the impedance levels appear to be random. Statistical analysis (ANOVA) confirmed the appearances. As shown in Table 2, the numbers of conflicts were statistically different between the two speed categories and the three volume categories. There were fewer conflicts in the above 45 mph speed range than in the 45 MPH and below speed range. Accordingly, those wide loads traveling in the above 45 mph speed range had a lower potential for accidents than the other wide load vehicles.

Pearson correlation coefficients were calculated between speed, conflicts, impedance, and volume to see if any relationships existed between the variables (see Table 3). Speed showed a significant negative correlation with both conflicts and volume; i.e., as the speed increased, the number of conflicts and the volume moving in the same direction decreased. Partial correlation coefficients were calculated to control for whatever effects volume may have had

TABLE 2

MEAN CONFLICTS AND IMPEDANCE FOR
INTERSTATE AND FOUR-LANE DIVIDED HIGHWAYS

Speed Range	Mean Number of Conflicts			Mean Impedance		
	Low Volume	Medium Volume	High Volume	Low Volume	Medium Volume	High Volume
20-45	0.07 (6)	0.25 (18)	0.51 (20)	5.9 (6)	23.5 (18)	10.2 (20)
46-65	0.04 (21)	0.10 (8)	0.02 (7)	6.1 (21)	4.3 (8)	11.6 (7)

Note 1: The numbers in parentheses are the numbers of valid trips in the categories.
Note 2: Volume, conflicts, and impedance are normalized for length.
Note 3: Although some sample sizes are relatively small, the cells are orthogonal.

ANOVA: Main effect of speed, $F = 10.91$; Significant at $p < .05$ level.
(Conflicts) Covariate effect of volume; $F = 33.34$; Significant at $p < .05$ level.

ANOVA: Main effect of speed, $F = 2.076$, Not significant.
(Impedance) Covariate effect of volume, $F = 1.973$, Not significant.

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on the correlation between speed and conflicts. The partial correlation results are also shown in Table 3. The figures show that the number of conflicts decreased as the speed increased, even when controlling for the effects of volume. These results are entirely in accordance with the results of the analysis of variance discussed above.

TABLE 3

PEARSON AND PARTIAL CORRELATION COEFFICIENTS
FOR INTERSTATE AND FOUR-LANE DIVIDED HIGHWAYS (80 CASES)

Variable	Pearson Correlation			Partial Correlation (Controlling Volume)	
	Speed	Conflicts	Impedance	Speed	Conflicts
Conflicts	-.5697 P = .001*	-	-	-.3560 p = .001*	-
Impedance	-.1049 P = .177	.2669 P = .008*	-	-.0695 P = .271	.2808 P = .006*
Volume	-.5105 P = .001*	.6718 P = .001*	-.0889 P = .271	-	-

The conclusion to be drawn from the data is that under the theory of traffic conflicts, the accident potential of wide load vehicles decreased as their speed increased.

When the data for interstate and four-lane divided highways were analyzed separately, the analyses of variance did not show that the levels of conflicts and impedance were different between the 45 mph and below category and the above 45 mph category; that is, the differences between the two speed groups which showed up when interstate and four-lane divided highways were combined were not apparent when the highways were analyzed separately. This result was probably because there were few trips below 45 mph (5 of 28) on interstate highways and relatively few trips above 45 mph (13 of 52) on four-lane divided highways.

Two-Lane Highways

The data from two-lane highways were analyzed to provide a comparison with multilane highways. None of the trips on two-lane highways had an average running speed greater than 45 mph.

Two speed categories were used for analysis in order to obtain meaningful cell sample sizes. The mean number of conflicts and impedance for each category and the ANOVA results appear in Table 4. The levels of conflicts and impedance were not statistically different between the speed categories but were different for the volume categories. The volume appeared to influence the number of conflicts and impedance much more than the speed did. The Pearson and partial correlation coefficients also support this observation (See Table 5). Of particular interest were the correlation coefficients between volume, conflicts, and impedance. Since reducing the volume in the same direction was equivalent to reducing the speed differential between the wide load vehicle and the rest of the traffic, this result was in accordance with the studies reviewed previously.

TABLE 4

MEAN CONFLICTS AND IMPEDANCE FOR TWO-LANE HIGHWAYS

Speed	Mean Number of Conflicts			Mean Impedance		
	Low Volume	Medium Volume	High Volume	Low Volume	Medium Volume	High Volume
10-30	0.75 (23)	0.68 (13)	2.85 (11)	10.9 (23)	94.7 (13)	514.1 (11)
31-45	0.37 (17)	1.57 (10)	1.90 (8)	40.2 (17)	235.7 (10)	472.5 (8)

Note 1: The numbers in parentheses are the numbers of valid trips in the categories.
Note 2: Volume, conflicts, and impedance were normalized for length.

ANOVA: Main effect of speed, $F = 0.369$, Not significant.
(Conflicts) Covariate effect of volume, $F = 30.278$, Significant at $p \leq .01$ level.

ANOVA Main effect of speed, $F = 0.574$, Not significant.
(Impedance) Covariate effect of volume, $F = 41.257$, Significant at $p \leq 0.1$ level.

TABLE 5

PEARSON AND PARTIAL CORRELATION COEFFICIENTS
FOR TWO-LANE HIGHWAYS (82 CASES)

Variable	Pearson Correlation			Partial Correlation (Controlling Volume)	
	Speed	Conflicts	Impedance	Speed	Conflicts
Conflicts	-.1793 P = .053	-	-	.0155 P = .446*	-
Impedance	-.0923 P = .205	.6887 P = .001	-	.2055 P = .033*	.1400 P = .10
Volume	-.2453 P = .013*	.7699 P = .001*	.8297 P = .001*	-	-

The conclusion reached concerning two-lane highways was that reducing the speed differential reduced the traffic conflicts and impedance. However, increasing the speed of the wide load vehicles did little to reduce the speed differential. Further conclusions could not be made without conducting additional experimental research.

CONCLUSIONS AND RECOMMENDATIONS

In summary, it was found that the number of conflicts decreased as the speeds of the wide load vehicles increased on interstate and four-lane divided highways. No effects on impedance were noted. Those wideloads which had an average running speed greater than 45 mph had fewer conflicts than those wide loads which had an average running speed lower than 45 mph. According to traffic conflicts theory, reducing conflicts reduces accident potential; therefore. the wide loads which had speeds greater than 45 mph are hypothesized to have had a lower accident potential than the wide loads traveling at lower speeds. This is likely because the faster moving wide loads were probably traveling closer to the mean speed of the traffic stream and thus had a reduced speed differential. This reduced speed differential is related to reduced accident rates as was discussed in the literature noted previously in this memorandum.

Speed has a questionable effect on the number of conflicts and impedance on two-lane highways, but the speed differential, as indicated by the volume in the same direction, had a decided effect. Additional research should be conducted to determine how best to reduce the speed differential for wide loads on two-lane highways.

It is recommended that the speed limit for over width mobile homes and modular housing units on interstate and four-lane divided highways be raised to 55 mph. The speed limit for other wide loads should probably also be raised, but this recommendation cannot be made on the basis of the analysis made because the data pertain to mobile homes and modular housing units only.

The specific recommended change to the Virginia Code is to modify the first sentence of §§46.1-193 (1)(e) to read as follows:

> *"(e) Forty-five miles per hour on any highway if the vehicle or combination of vehicles is operating under a special permit issued by the State Highway and Transportation Commission in accordance with §§46.1-330 and 46.1-343, unless such vehicle or combination of vehicles is a mobile or modular housing unit being transported on interstate or four-lane highways with divided roadways and operating under a special permit solely because of exceeding the maximum width specified in §46.1-328."*

The implementation of this recommendation would reduce the accident potential and transportation costs of over width mobile homes and modular housing units on the highways of Virginia.

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