Empirical Analysis of Truck and Automobile Speeds on Rural Interstates: Impact of Posted Speed Limits

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ABSTRACT

Posted speed limit settings on rural highways have always been a point of contention with different stakeholders having very different perspectives (motorist, enforcement, commercial trucking, etc.). In particular, the effect of the posted speed limit on safety has been widely studied, primarily using accident data bases. The results reported in the literature are often inconclusive or even contradictory. In addition, many speed-related safety and environmental objectives are in conflict with mobility goals. An important aspect of this research relates to the impact of posted speed limits on actual traffic behavior. This study investigated the speed distributions for both heavy trucks and light vehicles (cars) at 19 rural interstate highway sites across the United States. The speed limit configurations were selected to encompass the full range of posted limits (55 mph to 75 mph) and to include both uniform and differential speed limits (e.g., 55 for trucks and 70 for cars). The results of the study describe the actual distribution of speeds for trucks and cars across the various speed limit configurations. In addition, the mean speeds, 85^{th} percentile speeds, compliance rates and observed speed differentials are reported for the individual sites and for each speed limit configuration. The final set of data demonstrates the effect of increased fuel costs on the distribution of truck and car speeds. The results of the study provide an important contribution to the discussion of appropriate maximum speed limits, as well as the natural differential speeds that exist between heavy trucks and light vehicles.

Keywords: trucking, safety, speed limits, operations, differential speed limits

BACKGROUND

The determination of appropriate speed limits has been an issue for over 100 years, and likely existed prior to horseless carriages (“Trot Only” signs for horses). There is a large literature base on the effect of speed on safety (*1*, *2*, *3*, *4*). In addition, there is increasing attention on the effect of travel speed with respect to fuel conservation and the environment (*5*). Today, the setting and posting of traffic speed limits is vested in local and state agencies, even for federal highways and interstates. Across the United States, there are large differences in the posted speed limits on similarly designed highways (Figure 1). For example, it is legal for a heavy truck to go 15 miles per hour faster on some two-lane highways in Texas than on a rural interstate in California or Illinois. Similarly, there is a 20 mph difference in the speed limit on the same highway (I-10) when a truck crosses the state line from California to Arizona. The highway design speed is the same on both sides of the state line, but the posted speed limits are very different (55 mph versus 75 mph for trucks). Some states have speed differentials between heavy trucks and other vehicles on rural interstate highways (e.g., 15 mph in California) and other states have uniform speed limits for trucks and other vehicles (65, 70 or 75 mph). Although there are many strongly held views relating to appropriate maximum speed limits, there is actually very little conclusive support for any of the various configurations in use today.

Figure 1 Differences in Posted Speed Limits on Different Roadways

There is currently an extensive amount of data being collected by state and federal highway departments on the amount of traffic volume on highways, including interstates. The documentation often provides the volume information by vehicle classification (heavy trucks versus light vehicles). In addition, data are continuously being collected on traffic speed on various roadways. However, although it appears to be technically feasible, speed data separated by vehicle classification (e.g., heavy trucks versus light vehicle) is rarely collected and analyzed. As part of a complete discussion of appropriate speed limits, it is important to understand how posted limits affect traffic behavior. It is also important to understand how truck traffic differs from other vehicles with respect to speed. The objective of this study was to collect empirical data on the separate distributions of truck and car speeds on rural interstates that have different speed limit configurations.

This effort was funded by the American Transportation Research Institute (ATRI) and is a continuation of an ongoing study of the effects of speed differentials between heavy trucks and other vehicles on rural interstate highways. The previous work was conducted by the author under contract with the Mack Blackwell Rural Transportation Center at the University of Arkansas (*6*, *7*). During that effort, data were collected from the Midwest region (Arkansas, Missouri, and Illinois). The objective of the current study was to broaden the geographic regions and to include all posted speed limit configurations that occur on rural interstates in the United States.

RESEARCH METHOD

Nineteen rural interstate locations were selected across the United States that provide the full range of different speed configurations that exist on rural interstates. Some of the locations had uniform speed limits for trucks and cars, others had speed differentials. The posted speed limits for cars were 65, 70 and 75 mph and the posted limits for trucks were 55, 60, 65, 70 and 75 mph. The speed differentials levels that were studied included 0, 5, 10 and 15 mph. Figure 2 illustrates the locations where speed data were collected. The data collection sites are labeled with the posted speed limits (e.g., 55/65 for the truck and car speed, respectively).

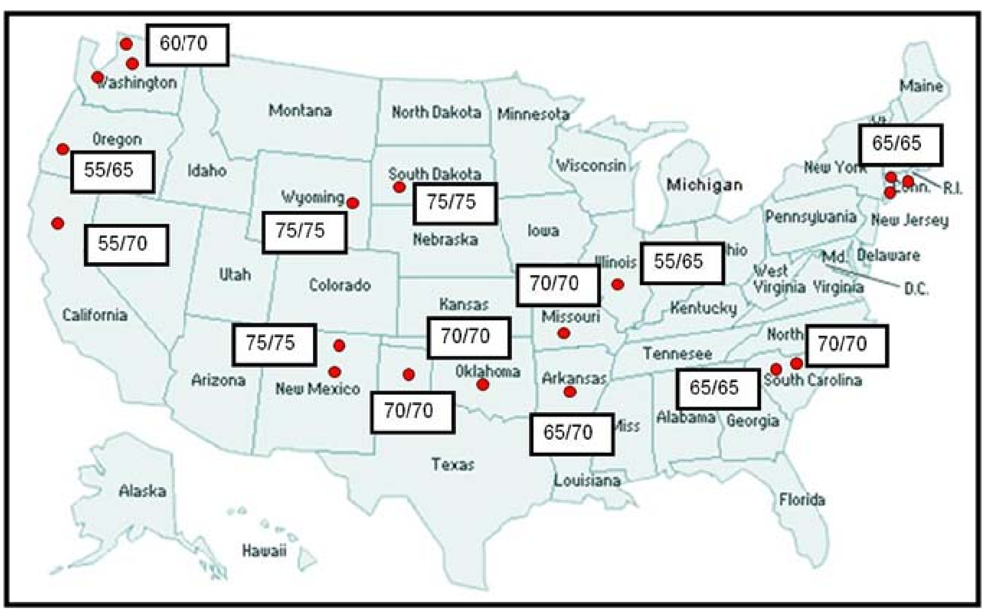

Figure 2 Locations of the Data Collection Sites

The data were collected in both travel directions (N-S/E-W) at each site. No significant design or operational difference was observed between the directions at any site and the measurements were combined. Three sites (I-5 in Washington, I-84 in Connecticut, and I-85, South Carolina, I-5 Washington) were six-lane highways (three lanes in each direction). All other highways were four-lane interstate highways.

All sites were on rural interstate highways that were flat and relatively straight for at least two miles prior to the site. The data collected do not represent traffic behavior on highways that have lower design speeds due to different highway geometries. The data were collected during weekdays (Monday thru Friday) in the morning (9:00-11:00) or afternoon (2:00-4:00). During the data collection periods, the weather was clear and visibility was good. The speeds of both trucks and cars were measured with a Prolaser II, Doppler lidar, manufactured by Kustom Signals, Inc. When collecting traffic speed data, the relative levels of enforcement can obviously affect the result. Although it is difficult to characterize the enforcement levels at the various sites, there were no speeding citations observed to be administered at any site during any of the data collection periods.

Only heavy combination trucks (class 8) were included as "trucks." Similarly, in this paper, the term "cars" refers to personal vehicles (sedans, SUVs, mini-vans, etc.). In addition, only the speeds of "unrestricted" vehicles were measured; vehicles restricted by a leading vehicle were not measured. For this reason, the average speeds presented in this report might be slightly higher than the total mean traffic speeds. A pilot study indicated that this constrain affected the light vehicle averages only slightly (less than 0.1 mph) and did not affect the truck speed estimates. This is due to the fact that light vehicles are sometimes slowed by trucks, but the reverse seldom occurs.

RESULTS

Table 1 presents the data for each of the sites in increasing order of the posted truck speed limit. Figure 3 illustrates the proportion of unrestricted trucks and cars that were observed to be travelling at various speeds on I-5 in California where the truck and car speed limits are 55 mph and 70 mph, respectively. This represents the highest posted speed differential in the United States. From Table 1, it can be seen that the average speeds were 61.2 mp and 72.6 mph, respectively for trucks and cars. The observed speed differential was, therefore, 11.4 mph. Figure 4 shows the observed distribution for I-40 in New Mexico that has the highest speed limit configuration of 75 mph for both trucks and cars. The average speeds were observed to be 68.9 mph and 76.8 mph for trucks and cars, respectively. The observed speed differential was 8.1 mph, even though it is a uniform speed limit configuration. This is likely due to the fact that many large commercial trucks have engine speed limiters that restrict the truck's speed (*8, 9, 10, 11*).

Figure 5 shows the average speeds for trucks and cars at all of the sites. The sequence of the sites is based on the increasing posted speed limits for trucks. The graph illustrates that the average speeds of the cars are relatively unaffected by the posted speed limits. Figures 6, and 7 illustrate the distributions across sites with similar maximum speed limits for trucks (55, 60, 65, 70, 75 mph) and cars (65, 70, and 75 mph), respectively. Figure 8 presents the average speeds for each of the posted speed limit configurations. Although, for trucks, there was a 20 mph difference between the highest and lowest posted limit, there was only a 6.3 mph increase in the average speed. Similarly, although there was a 10 mph difference for cars, the change in average speed was less only 3.7 mph.

Table 1 Statistical Measures for Highways

State	Hwy	Speed Limit		Sample Size		Average Speed (mph)		Std Dev.		85^{th} % Speed		Compliance		Differential
		Trucks	Cars	Trucks	Cars	Trucks	Cars	Trucks	Cars	Trucks	Cars	Trucks	Cars	
CA	I - 5	55	70	277	213	61.2	72.6	3.62	4.78	65	77	3.2	8.9	11.4
IL	I - 57	55	65	262	878	64.2	73.2	4.00	5.67	68	79	0.0	7.2	9.0
OR	I - 5	55	65	273	288	60.9	70.0	2.87	4.52	64	75	1.5	14.9	9.1
WA	I – 5 *	60	70	139	111	63.3	71.7	3.04	4.07	67	76	17.3	34.2	8.4
WA	I – 5	60	70	154	146	64.5	71.6	2.67	3.52	67	75	22.0	35.6	7.1
WA	I - 90	60	70	246	159	62.9	72.9	3.28	4.09	66	76	22.0	26.4	10.0
CT	I - 395	65	65	184	129	66.4	72.7	3.80	4.53	70	78	45.2	5.4	6.3
CT	I – 84*	65	65	156	144	66.0	73.6	3.16	5.21	69	78	50.0	5.6	7.6
CT	I - 95	65	65	212	121	66.1	72.0	3.44	4.68	70	70	43.4	8.6	5.9
SC	I – 85*	65	65	433	574	67.2	69.9	4.12	5.29	71	76	35.1	20.6	2.7
AR	I - 40	65	70	169	362	66.7	73.5	3.69	4.32	70	78	32.5	21.8	6.8
SC	I - 26	70	70	276	588	69.0	72.5	4.00	5.32	73	77	64.5	28.6	3.5
MO	I - 44	70	70	247	611	68.6	72.6	4.55	4.95	73	77	69.6	31.4	4.0
TX	I - 40	70	70	131	89	68.6	71.4	3.63	3.98	72	75	76.3	75.3	2.8
OK	I - 40	70	70	168	173	69.4	72.9	3.38	3.84	72	76	57.7	38.7	3.5
NM	I - 25	75	75	36	120	68.9	76.8	5.97	4.24	75	81	86.1	38.3	7.9
NM	I - 40	75	75	276	239	68.0	75.5	4.20	4.75	73	80	98.2	51.1	7.5
SD	I - 90	75	75	193	213	67.0	74.7	4.00	4.21	71	79	98.9	54.9	7.7
WY	I - 90	75	75	140	164	69.8	75.3	4.85	4.45	75	79	91.4	47.9	5.5

* six-lane highways

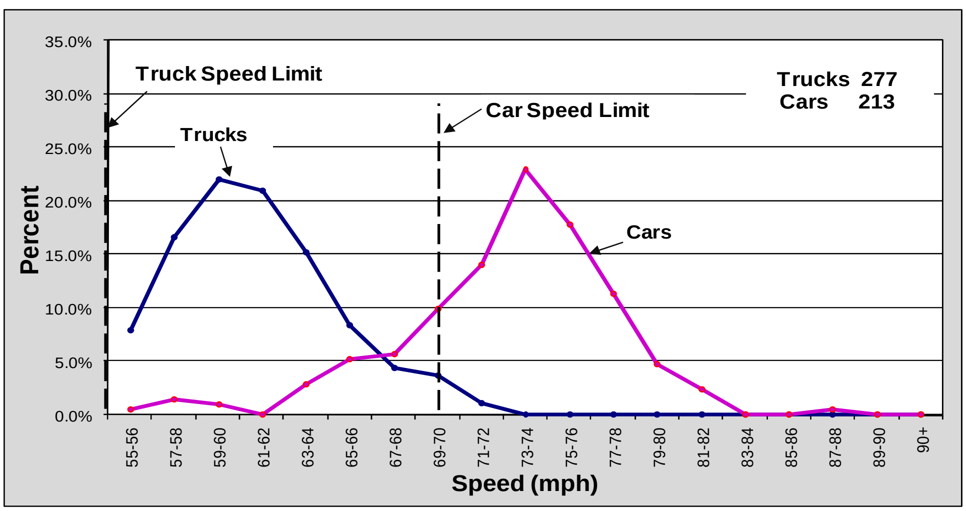

Figure 3 Distribution of Speeds on I-5 in California (Trucks, 55 mph; Cars, 70 mph)

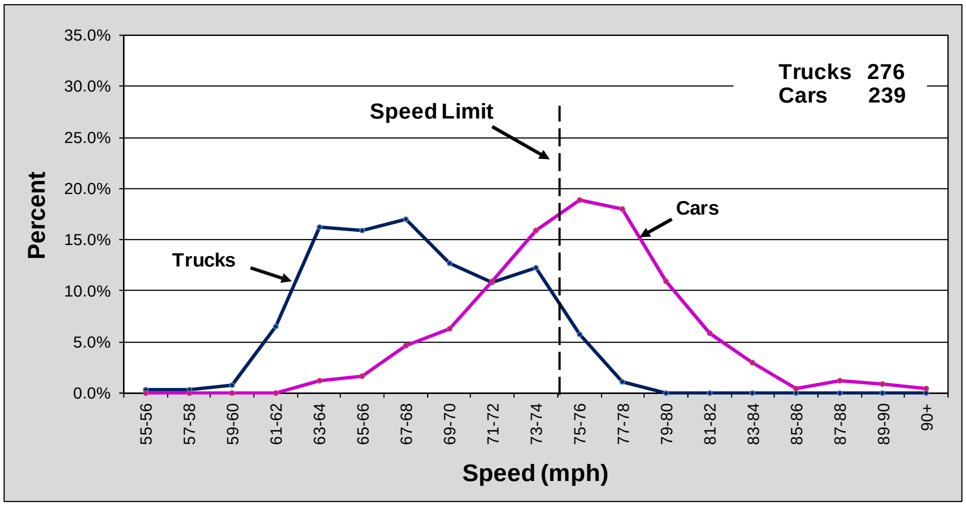

Figure 4 Distribution of Speeds on I-40 in New Mexico (Trucks and Cars, 75 mph)

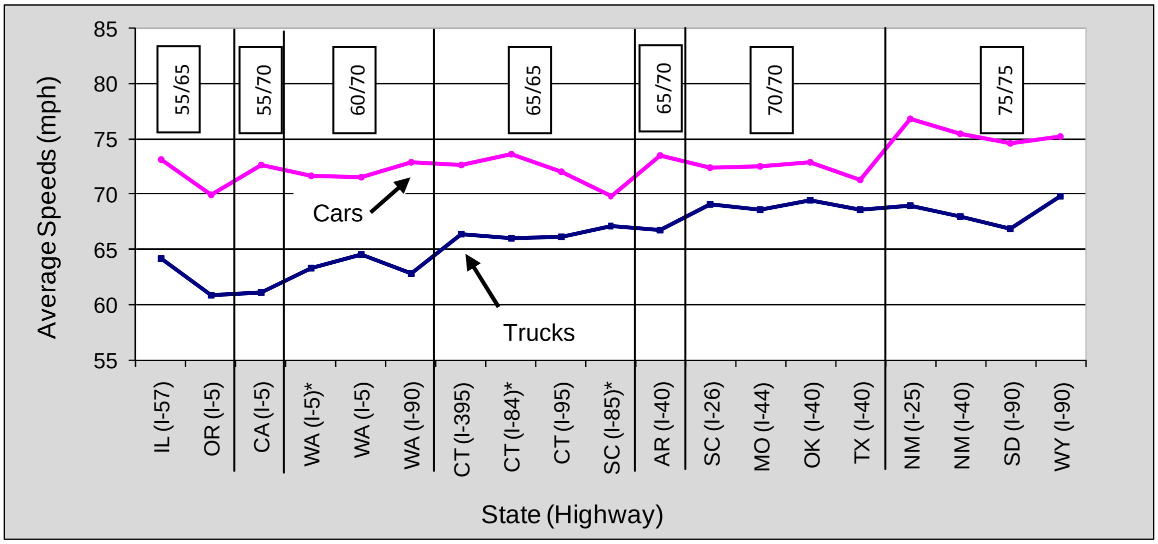

Figure 5 Average Speeds for Trucks and Cars for Sites

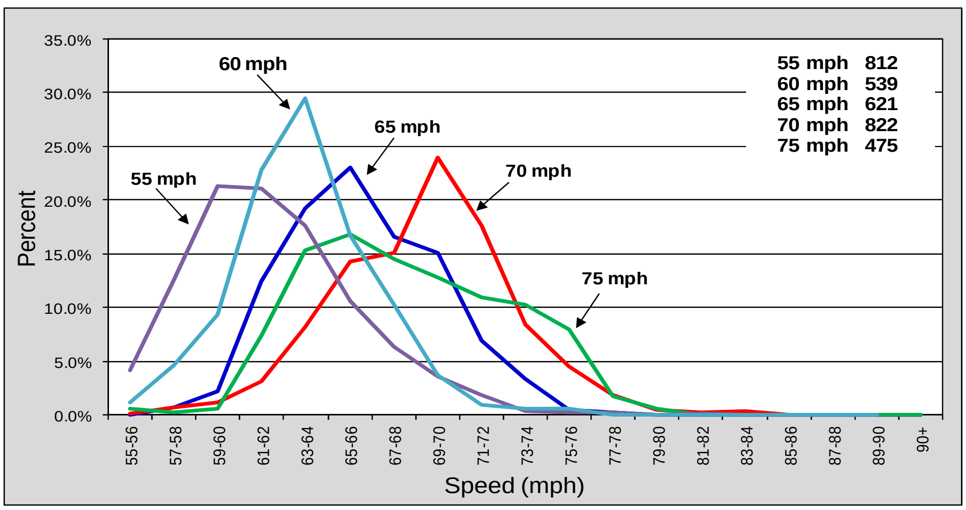

Figure 6 Speed Distribution by Posted Speed Limit – Trucks (mph)

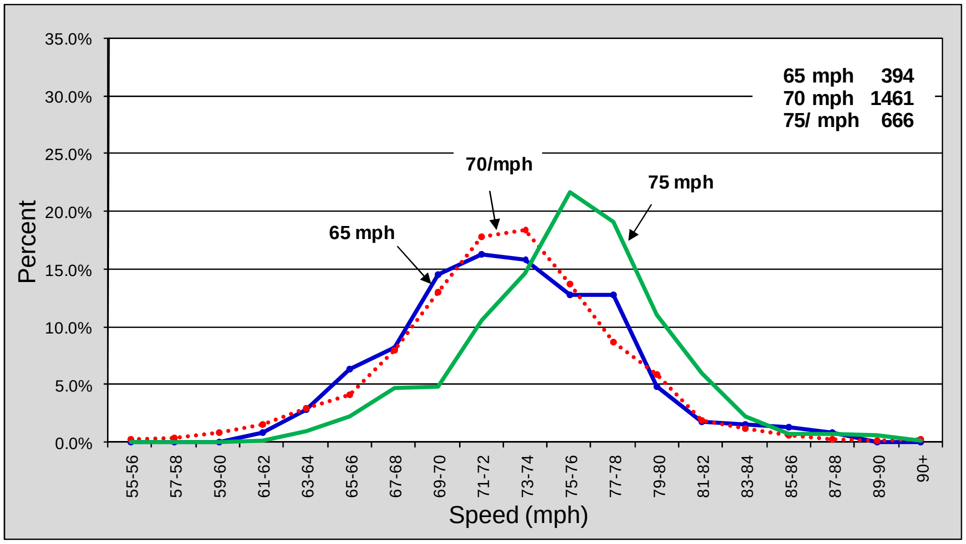

Figure 7 Speed Distribution by Posted Speed Limit – Cars (mph)

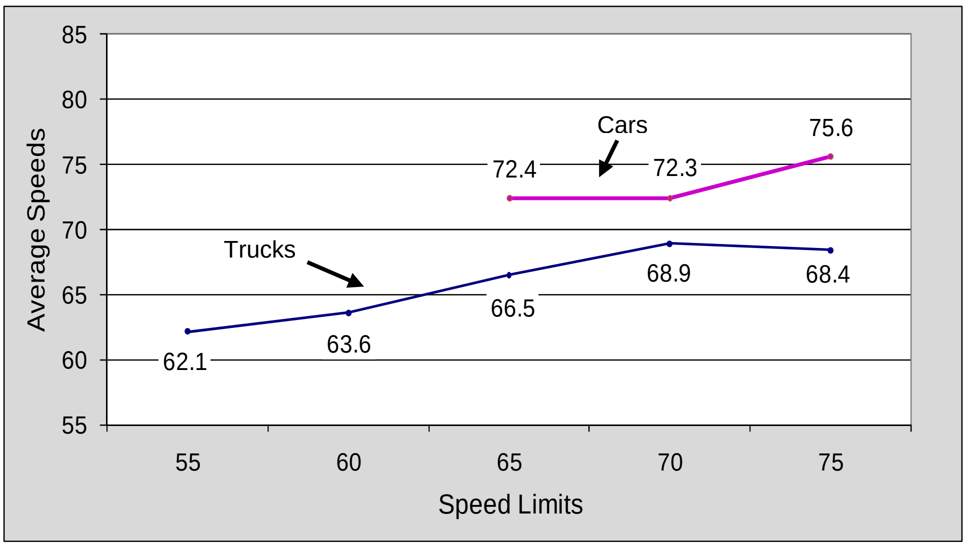

Figure 8 Average Speed by Posted Speed Limit

Figure 9 illustrates the observed speed differentials between trucks and cars as a function of the posted speed differential. The data illustrate that even for the uniform speed configuration there is an effective (i.e., "natural") differential between trucks and cars. The research studies that have investigated the safety effects of speed differentials by comparing the data from different states (e.g., with and without differentials) have not taken this fact into account. It is not surprising, therefore, that the results of these studies have been inconclusive. Similarly, any analysis that is based on different posted limits also relies on the assumption that the traffic behavior is affected or attenuated by the limits. That is, to the extent that the traffic behavior is based on the design speed of the highway rather than the posted limit, the distribution of speeds would be relatively similar, even though the posted limits are different. If the traffic speed is relatively unaffected by the posted limits, safety studies that rely on archival accident data bases and posted limits would have limited utility

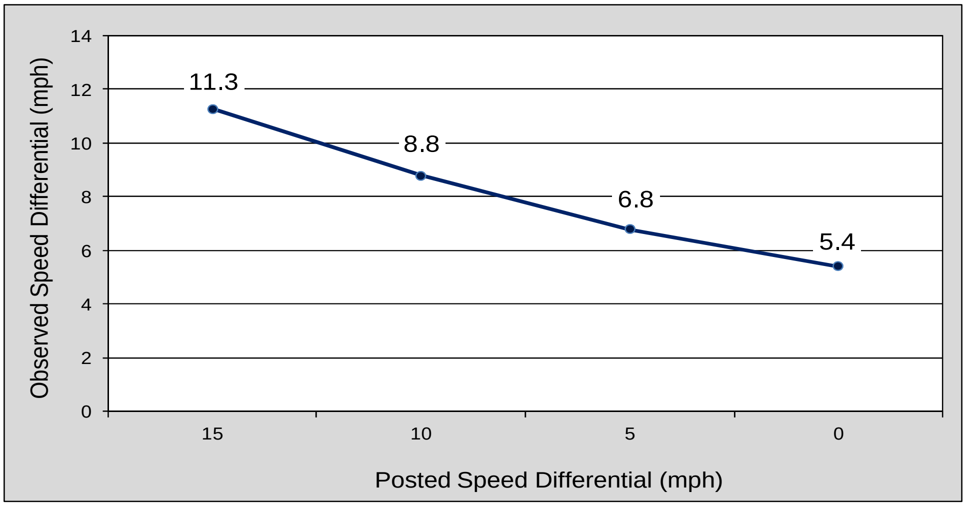

Figure 9 Observed Speed Differentials for Different Posted Differentials

Another statistical characteristic of the traffic speeds that is important in the context of establishing appropriate speed limits is the 85th percentile speed. The document, *Design Speed, Operating Speed and Posted Speed Practices* published by the National Cooperative Highway Research Program (*12*), states that "the [highway design] profession has a goal to set posted speed limits near the 85th percentile speed." (p. 2) An important characteristic of the concept of using the 85th percentile as a "design speed" is the assumption that the measurements are of "free flowing," uninhibited traffic. Strictly speaking, that would refer to the speed adopted by motorists if there were no posted speed limit, which is obviously not the case.

Figure 10 illustrates the 85th percentile speeds for trucks and cars for all sites. As with the graphs of the average speeds, this figure illustrates that the 85th percentile speed for cars is relatively insensitive to the posted speed limit, particularly for 65 versus 70 mph limits.

Figure 11 presents the 85th percentile speeds for the various posted speed limits configurations. The data indicate that the 85th percentile speed for trucks increased by only one (1) mph when the posted speed limit increases by five (5) mph (from 70 to 75 mph). Again, this is likely related to the fact that the majority of commercial trucks have speed limiters.

Figure 12 gives the compliance rates for trucks and cars as a function of the posted speed limits. Compliance increases for both trucks and cars as the posted limits increase. However, it should be noted that there is virtually no compliance on the interstates with a 55 mph posted truck speed. For example, there were no trucks observed in Illinois that were going at or below the posted limits (compliance is zero). Similarly, the observed compliance for cars in Illinois was only seven percent.

One of the factors that can affect the drivers' choices of speed is the cost of fuel. To evaluate this factor, data were collected under different fuel costs to compare the speed distributions. Speed data for both trucks and cars were collected on I-40 in Arkansas during June, 2004 (diesel, $1.79/gal.; gasoline, $1.80/gal.), January 2008 (diesel, $3.30/gal., gasoline,$3.00/gal.) and June 2008 (diesel, $4.70/gal.; gasoline, $4.04/gal.). Tables 13 and 14 provide the speed distributions for trucks and cars as a function of the price of fuel. Table 2 provides the mean and standard deviation for the speed data. It is important to note that the effect of "surcharges" that some commercial fleets charge their customers to offset higher fuel prices is not taken into account. Therefore, the cost of fuel at the site does not necessarily represent the cost paid by all truck owners.

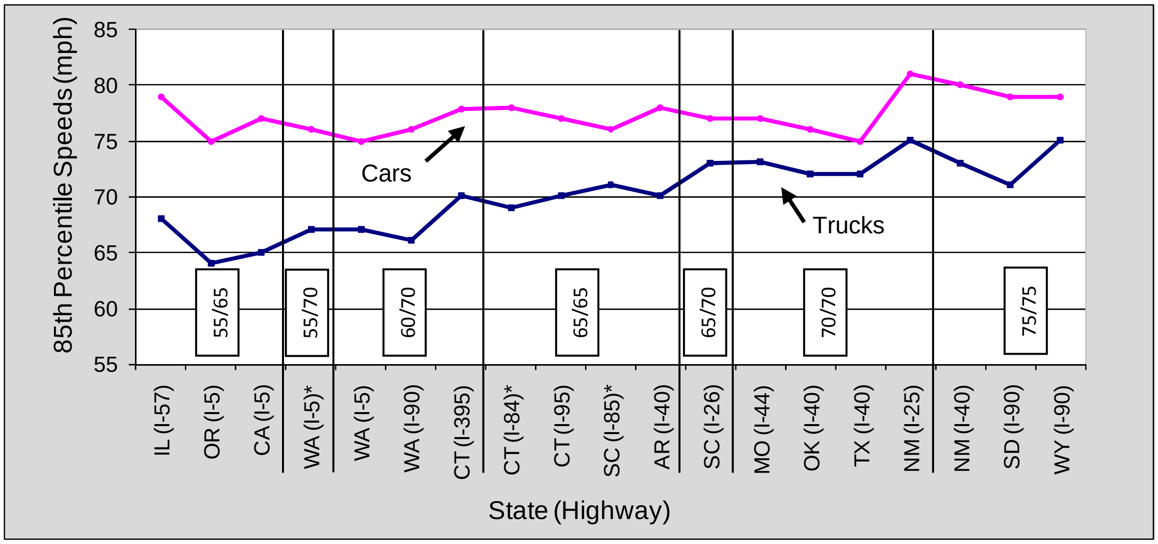

Figure 10   85th Percentile Speed for Trucks and Cars Speeds for All Sites

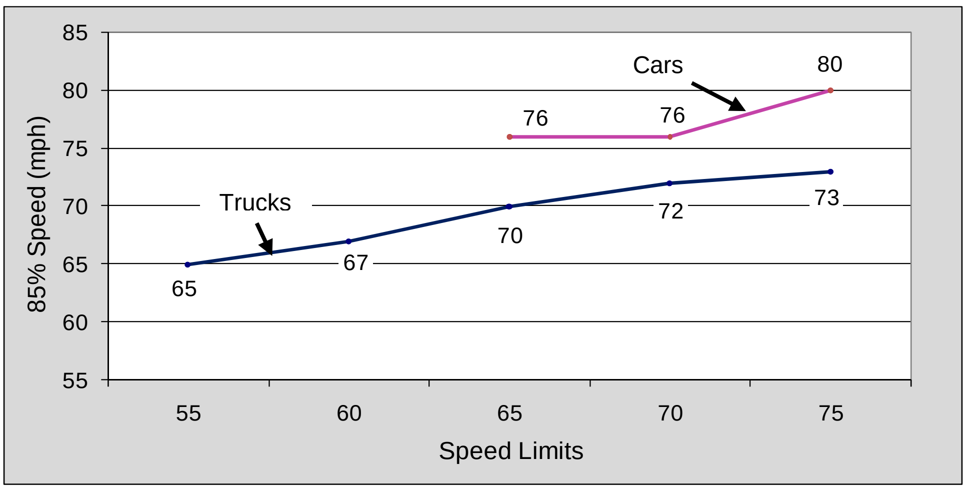

Figure 11   85th Percentile Speed by Posted Speed Limit

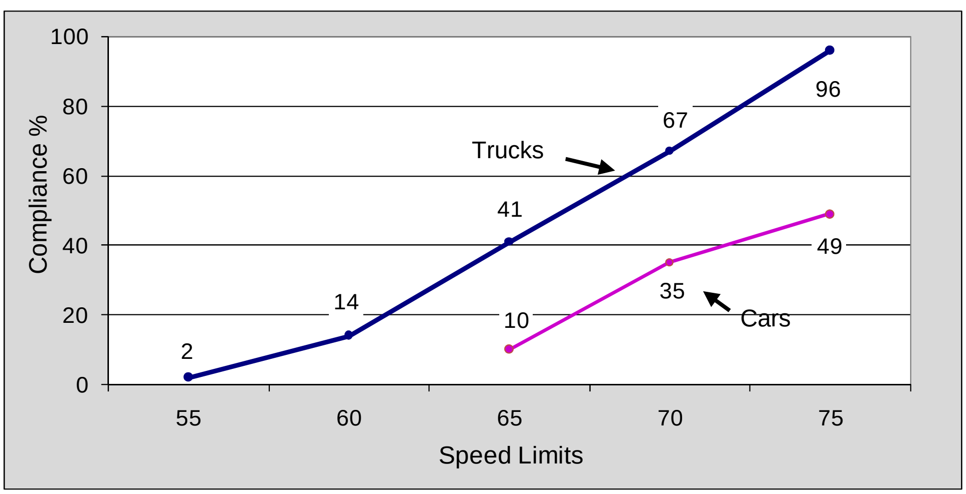

Figure 12   Compliance for Trucks and Cars by Posted Speed Limit

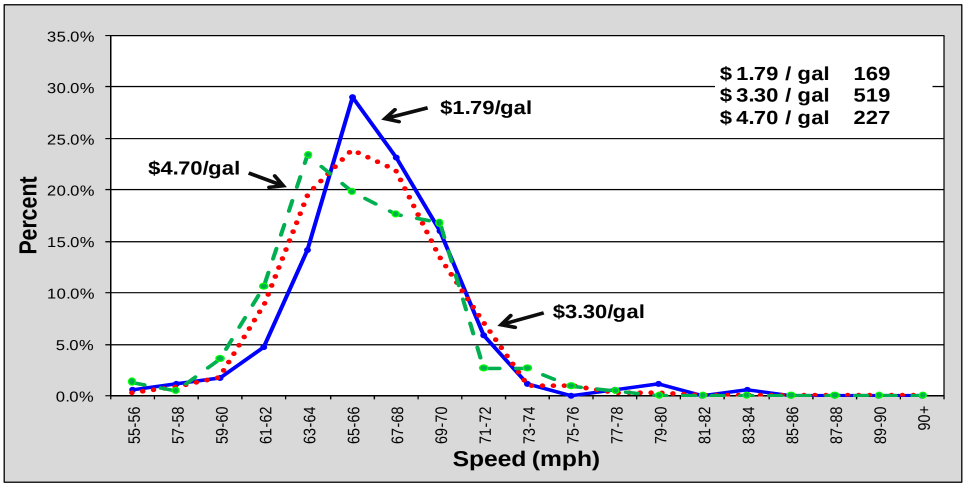

Figure 13 Comparison of Speed Distribution for Different Fuel Costs for Trucks

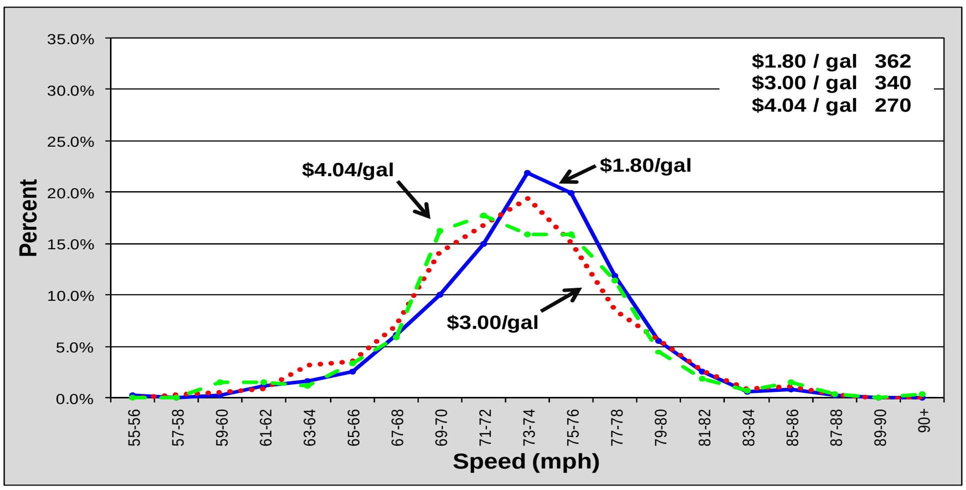

Figure 14 Comparison of Speed Distributions for Different Fuel Costs for Cars

Table 2 Comparison of Seed Distributions for Different Fuel Costs for Trucks and Cars

	Trucks (Diesel)			Cars (Regular)		
	$1.79	$3.30	$4.70	$1.80	$3.00	$4.04
Average	66.7	66.2	65.7	73.5	72.8	72.9
Std Dev	3.69	3.24	3.68	4.32	4.68	4.82

The data indicate that although the distribution of vehicle speed changed when the price of fuel increased for both trucks and cars, the change was very small (less than one mph). For the trucks, in particular, it appears that the change was primarily for the larger fleets that lowered the settings on their speed limiting devices (e.g., from 65 to 62 mph). For both the trucks and the cars, it appears that the "medium" speed vehicles lowered their speed; whereas the "faster" vehicles continued to travel at the same speed as with lower fuel costs.

SUMMARY

This study is part of an ongoing effort to evaluate the impact of maximum speeds and speed differentials between heavy trucks and other vehicles (cars) on rural interstates. The goal of this portion of the effort was to provide empirical data on the speed distributions of trucks and cars to describe the actual speed behavior of traffic on rural interstates with different speed limit configurations. Posted speed limits for trucks vary from 55 mph in some states (e.g., California) to 75 mph in many of the Midwest and Western states. Speed data were collected at 19 rural interstates sites across the United States that had posted speed limits of 55, 60, 65, 70 and 75 mph for trucks and 65, 70 and 75 mph for cars. Speed data were collected at sites with speed differentials of zero (uniform), 5, 10 and 15 mph. The report provides graphs of the speed distributions and summary statistics for trucks and cars at each site.

The summary statistics include: average (mean) speeds, 85th percentile speeds, compliance and observed speed differentials. A number of conclusions can be drawn from the results of the study. First, both the average and the 85th percentile speeds for cars are relatively unaffected by the posted speed limits on rural interstates. For example, the observed compliance rate of cars on interstate in Illinois with a 55 mph speed limit was seven (7) percent. The corresponding observed compliance rate for trucks on the same Illinois interstate that had a 55 mph posted limit for trucks was zero (0) percent. The compliance rate for trucks on rural interstates with a uniform 75 mph posted limit was 96 percent; however, the compliance rate for cars on these higher speed interstates was still only 49 percent. Although average truck speed did increase with each increase in the posted limit, the 20 mph range for the posted truck speed limits (55 to 75 mph) resulted in only a 7 mph increase in the average speed for trucks (61.7 to 68.8 mph). The final conclusion of the study is that, although the cost of fuel does alter the speed distributions for both trucks and cars to some extent, the reduction in average speed was relatively small (1 mph for trucks and 0.5 mph for cars).

The objective of this study was to provide information that commercial companies, regulatory agencies and the general public can use in the discussions related to posted and natural speed differentials on rural highways. To have a meaningful discussion, it is necessary to understand the speed characteristics of trucks and cars for the different speed limit configurations.

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