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Evaluation of the Impacts of Differential Speed Limits on Interstate Highways in Idaho

By

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16. Abstract

In this research, an evaluation of the impacts of differential speed limits on rural interstate highways in Idaho was completed. The main purpose for this research was to determine if there have been any speed or safety effects after enacting the DSL, and also to study some of the geometric effects, like rumble-strips, on the safety of vehicles on rural Idaho interstates. Regarding the effects of DSL on speed, it was found that passenger car and truck speeds stabilized since the DSL policy implementation date. More specifically, the DSL reduced truck speeds, resulting in mean passenger vehicle and truck speeds of 74.7 and 65.6 mph, respectively. Regarding the DSL effect on speed compliance, Passenger vehicle compliance slightly worsened, while truck compliance improved. Establishment of the DSL policy also contributed to a decrease in the crash rates on Idaho's rural interstates.

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METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS					APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	When You Know	Multiply By	To Find	Symbol	Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH					LENGTH		
in	inches	25.4		mm	mm	millimeters	0.039	inches	in
ft	feet	0.3048		m	m	meters	3.28	feet	ft
yd	yards	0.914		m	m	meters	1.09	yards	yd
mi	Miles (statute)	1.61		km	km	kilometers	0.621	Miles (statute)	mi
		AREA					AREA		
in^2	square inches	645.2	millimeters squared	cm^2	mm^2	millimeters squared	0.0016	square inches	in^2
ft^2	square feet	0.0929	meters squared	m^2	m^2	meters squared	10.764	square feet	ft^2
yd^2	square yards	0.836	meters squared	m^2	km^2	kilometers squared	0.39	square miles	mi^2
mi^2	square miles	2.59	kilometers squared	km^2	ha	hectares (10,000 m^2)	2.471	acres	ac
ac	acres	0.4046	hectares	ha					
		MASS (weight)					MASS (weight)		
oz	Ounces (avdp)	28.35	grams	g	g	grams	0.0353	Ounces (avdp)	oz
lb	Pounds (avdp)	0.454	kilograms	kg	kg	kilograms	2.205	Pounds (avdp)	lb
T	Short tons (2000 lb)	0.907	megagrams	mg	mg	megagrams (1000 kg)	1.103	short tons	T
		VOLUME					VOLUME		
fl oz	fluid ounces (US)	29.57	milliliters	mL	mL	milliliters	0.034	fluid ounces (US)	fl oz
gal	Gallons (liq)	3.785	liters	liters	liters	liters	0.264	Gallons (liq)	gal
ft^3	cubic feet	0.0283	meters cubed	m^3	m^3	meters cubed	35.315	cubic feet	ft^3
yd^3	cubic yards	0.765	meters cubed	m^3	m^3	meters cubed	1.308	cubic yards	yd^3
Note: Volumes greater than 1000 L shall be shown in m^3									
		TEMPERATURE (exact)					TEMPERATURE (exact)		
^oF	Fahrenheit temperature	5/9 (^{o}F-32)	Celsius temperature	^oC	^oC	Celsius temperature	9/5 ^{o}C+32	Fahrenheit temperature	^oF
		ILLUMINATION					ILLUMINATION		
fc	Foot-candles	10.76	lux	lx	lx	lux	0.0929	foot-candles	fc
fl	foot-lamberts	3.426	candela/m^2	cd/cm^2	cd/cm^2	candela/m^2	0.2919	foot-lamberts	fl
		FORCE and PRESSURE or STRESS					FORCE and PRESSURE or STRESS		
lbf	pound-force	4.45	newtons	N	N	newtons	0.225	pound-force	lbf
psi	pound-force per square inch	6.89	kilopascals	kPa	kPa	kilopascals	0.145	pound-force per square inch	psi

Acknowledgements

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Executive Summary

Background

The Idaho Transportation Department (ITD) commissioned a study of the impact of the state's differential speed limit policy on highway safety. In 1998, policymakers lowered the speed limit for trucks traveling on Idaho's rural interstates from 75 mph to 65 mph. The speed limit reduction applied to all commercial trucks with five or more axles weighing more than 26,000 pounds (for convenience these are referred to as trucks). The new policy created a speed limit differential of 10 mph between these trucks and other vehicles. During the 2012 Legislative Session, the Senate Transportation Committee received a proposal to increase the truck speed limit to 75 mph. The Chairman of the Senate Transportation Committee asked the department to assess whether the lower truck speed limit has had a positive impact on safety and, working with other agencies and stakeholders, to develop recommendations about whether the current policy should be continued.

In April 1987, the United States Congress passed the Surface Transportation and Uniform Relocation Assistance Act (STURAA) to permit each state to increase speed limits from the formerly assigned 55 mph to 65 mph on the interstate highways. After passing this act, some states adopted the "Uniform Speed Limit" (USL), under which passenger vehicles and trucks have the same speed limit. Since 1987, Idaho had three different speed limit policies. First, Idaho adopted a uniform speed limit (USL) policy at 65 mph. Then, in 1996, the speed limit on Idaho's rural interstates was increased to 75 mph. Finally, in 1998, the Idaho legislature reduced the speed limit for trucks to 65 mph.

STURAA introduced flexibility to speed limit policies. With this flexibility, states began to vary the posted speed limits on rural freeways and Figure 1 illustrates current state posted speed limit variations. The map is color coded, with the legend on the right side. Eight states currently have a rural freeway Uniform Speed Limit (USL), unless otherwise noted on the map. In most cases, states maintain a USL policy on their rural freeways, making no special consideration for different vehicle types. Eight states currently maintain Differential Speed Limit (DSL) policies, which institutes different speed limits for passenger cars and trucks. These DSL states are indicated by notes on the figure, and include three of Idaho's neighboring states (Washington, Oregon, and Montana) as well as California.

Several arguments have been made for adopting the USL policy. One is that having different speed limits for passenger vehicles and trucks could increase speed differences between vehicles, increasing opportunities for collisions. Supporters of higher truck speed also have argued that truck-drivers can have more time to make decisions and react than passenger vehicle drivers because of their higher eye height in their elevated seat positions. However, this reasoning may not hold true at night. During the night, trucks have reduced traffic sign visibility because sign retroreflectivity is designed for passenger vehicle driver eye height. Another reason for allowing trucks to drive at the same speed as other vehicles is that it increases time efficiency.

The primary argument for adopting a DSL policy is that trucks require more distance and time to reach a full stop. In highway design, it is generally believed that this increased distance to stop negates the benefit of the increased truck-driver eye height.[1] In addition, crashes involving trucks tend to be more severe because of the combination of their mass and size.[2] Finally, as truck speeds increase, fuel efficiency decreases.

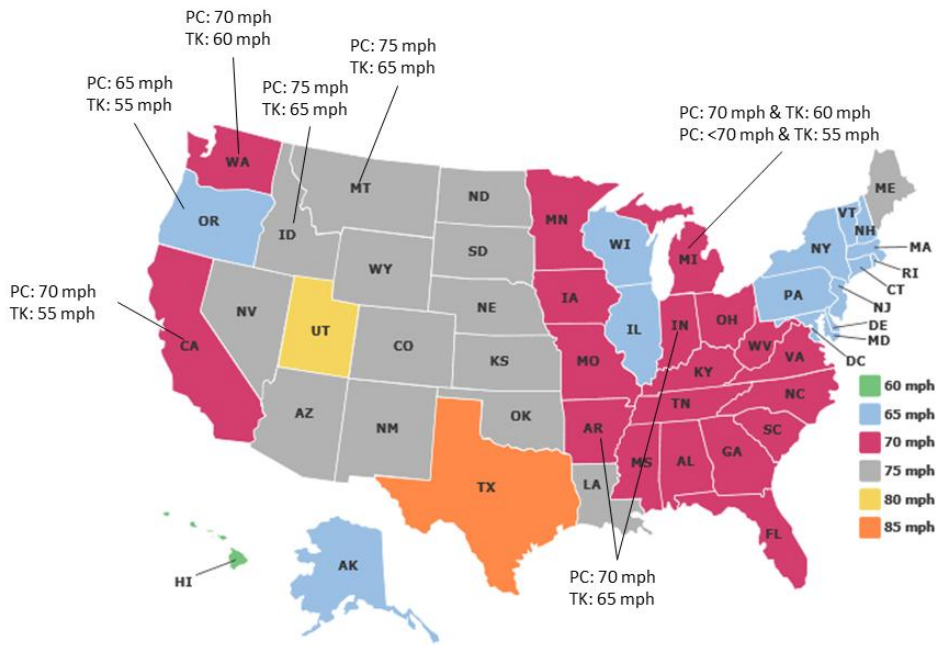


Figure 1. State Rural Interstate Posted Speed Limit Policies

There have been a number of previous studies on the relationship between speed limit policies and highway safety, [3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15] The prior research has not reached a consistent conclusion on DSL's safety effects. For instance, there has been no clear correlation between speed limits and crash rates in the previous research. In addition, the numerical differences in crash rates resulting from different speed limit policies were often found to be statistically insignificant)

The literature also gives several explanations for the difficulty in finding statistically significant effects that favor the DSL policy. This could be a law enforcement issue, where law enforcement leniency gives drivers too much latitude to choose their driving speed, disregarding the posted speed limits. This could also be due to the fact that many trucks have speed governors (for economic and safety reasons) that control the maximum speed limit for these trucks.

Results

As shown in Figure 2, in the year following implementation of the DSL policy, truck speeds dropped to a mean speed of 66.6 mph, a reduction of 2.1 mph in mean speed from the previous year. Truck speeds subsequently appear to have stabilized at close to the 65 mph speed limit. From 2009 to 2011, the average truck speed on Idaho's interstates was within 1 mph of the posted speed limit. At the same time, passenger vehicle mean speed increased by about 1 mph, creating an overall speed differential of about 9 mph. Figure 2 illustrates this trend, due in part to the effect of the DSL on vehicle speeds. Increased gas prices are another factor that may contribute to this trend.

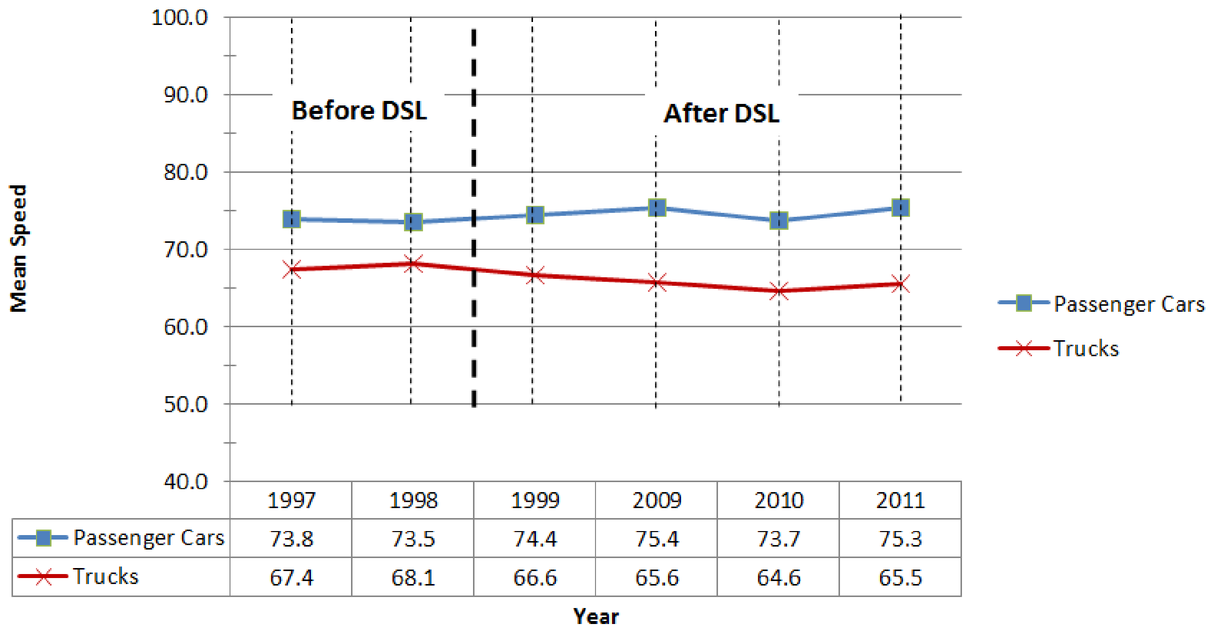


Figure 2. Idaho Rural Interstate Before-After Passenger Vehicle and Large Truck Mean Speeds

Truck speed limit compliance also improved significantly following implementation of the DSL policy. The percentage of trucks driving no more than five mph over the speed limit increased from 61 percent in 1998 to 86 percent in 2011. In contrast, passenger vehicle compliance slightly worsened.

As part of the study, crash data for Idaho's rural interstates were reviewed. Figure 3 shows the crash rates for all-vehicles and truck-involved crashes from 1992 to 2011. The figure shows that crash rates for all-vehicles declined from an average value of 0.92 to 0.68 per million vehicle miles traveled since the DSL law was established. For the same two time periods, truck-involved crash rates declined from an average value of 0.57 to 0.36 per million vehicle miles traveled. This represents a 26% and 38% crash rate reduction for all-vehicle crashes and for truck-involved crashes, respectively, showing a more pronounced downward trend for trucks. However, the number of crashes observed is much lower than the number of speed observations. In addition, the average crash rate from one year to the next occasionally had large variations. Severe weather is not a cause, because the data were taken from May and June. As a result, the conclusion that DSL improved safety is still valid, but it is not as significant relative to DSL's effect on truck speeds.

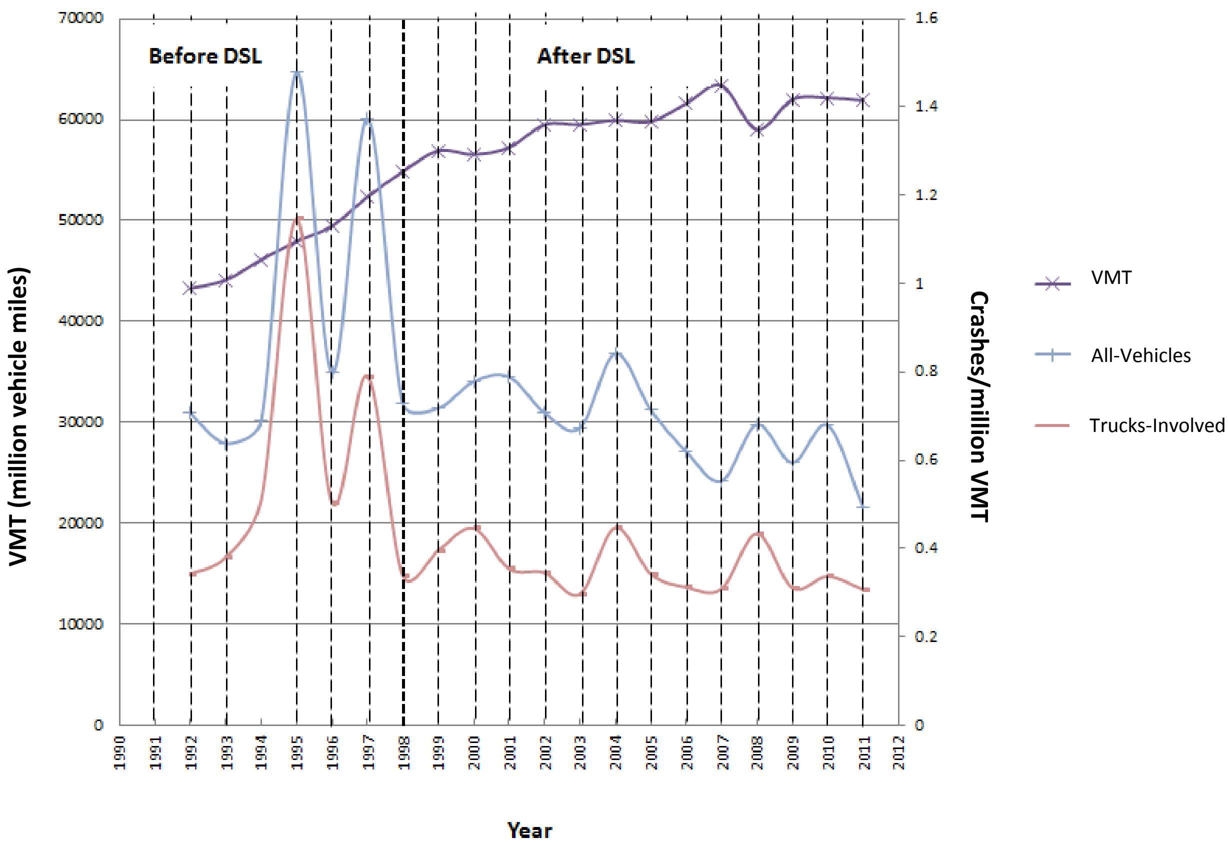


Figure 3. Idaho Rural Interstate Crash Rates

Conclusion

Implementation of Idaho's DSL policy had a noticeable safety benefit based on our analysis. The DSL policy favorably changed truck speeds, measured in terms of the reduction in average truck speed and the increase in the percentage of trucks complying with the posted speed limit. The state's DSL policy also contributed to a reduction in the truck-related crash rate. Because of these observed safety improvements, we recommend that Idaho's DSL policy be maintained to preserve current traffic safety trends.

Chapter 1
Introduction

In 1998, policymakers lowered the speed limit for trucks traveling on Idaho's rural interstates from 75 mph to 65 mph. The speed limit reduction applied to all commercial trucks with five or more axles weighing more than 26,000 pounds (for convenience these are referred to as trucks). The new policy created a speed limit differential of 10 mph between commercial trucks and other vehicles. During the 2012 Legislative Session, the Senate Transportation Committee received a proposal to increase the truck speed limit to 75 mph. The Chairman of the Senate Transportation Committee asked the Idaho Transportation Department (ITD) to work with other agencies and stakeholders to assess whether the lower truck speed limit has had a positive impact on safety and to develop recommendations about whether the current policy should be continued. The ITD commissioned a study of the impact of the state's differential speed limit policy on highway safety.

In April 1987, the United States Congress passed the Surface Transportation and Uniform Relocation Assistance Act (STURAA) to permit each state to increase speed limits from the formerly assigned 55 mph to 65 mph on the interstate highways. After passing this act, some states adopted the "Uniform Speed Limit" (USL), under which passenger vehicles and trucks have the same speed limit. Since 1987, Idaho had three different speed limit policies. First, Idaho adopted a uniform speed limit (USL) policy at 65 mph. On November 28, 1995, the national maximum speed limit was repealed, giving States further flexibility in setting their limits. As a result, in 1996, the speed limit on Idaho's rural interstates was increased to 75 mph. Finally, in 1998, the Idaho legislature reduced the speed limit for trucks to 65 mph.

STURAA introduced flexibility to speed limit policies. With this flexibility, states began to vary the posted speed limits on rural freeways and Figure 1 illustrates current state posted speed limit variations. The map is color coded, with the legend on the right side. All states have a rural freeway Uniform Speed Limit (USL), unless otherwise noted on the map. In most cases, states maintain a USL policy on their rural freeways, making no special consideration for different vehicle types. Eight states currently maintain Differential Speed Limit (DSL) policies, which institutes different speed limits for passenger cars and trucks. These DSL states are indicated by notes on the figure, and include three of Idaho's neighboring states (Washington, Oregon, and Montana) as well as California.

Several arguments have been made for adopting the USL policy. One is that having different speed limits for passenger vehicles and trucks could increase speed differences between vehicles, increasing opportunities for collisions. Supporters of higher truck speed also have argued that truck-drivers can have more time to make decisions and react than passenger vehicle drivers because of their higher eye height in their elevated seat positions. However, this reasoning may not hold true at night. During the night, trucks have reduced traffic sign visibility because sign retroreflectivity is designed for passenger vehicle driver eye height. Another reason for allowing trucks to drive at the same speed as other vehicles is that it increases time efficiency.

The primary argument for adopting a DSL policy is that trucks require more distance and time to reach a full stop. In highway design, it is generally believed that this increased distance to stop negates the benefit of the increased truck-driver eye height.(1) In addition, crashes involving trucks tend to be more severe because of the combination of their mass and size.(2) Finally, as truck speeds increase, fuel efficiency decreases.

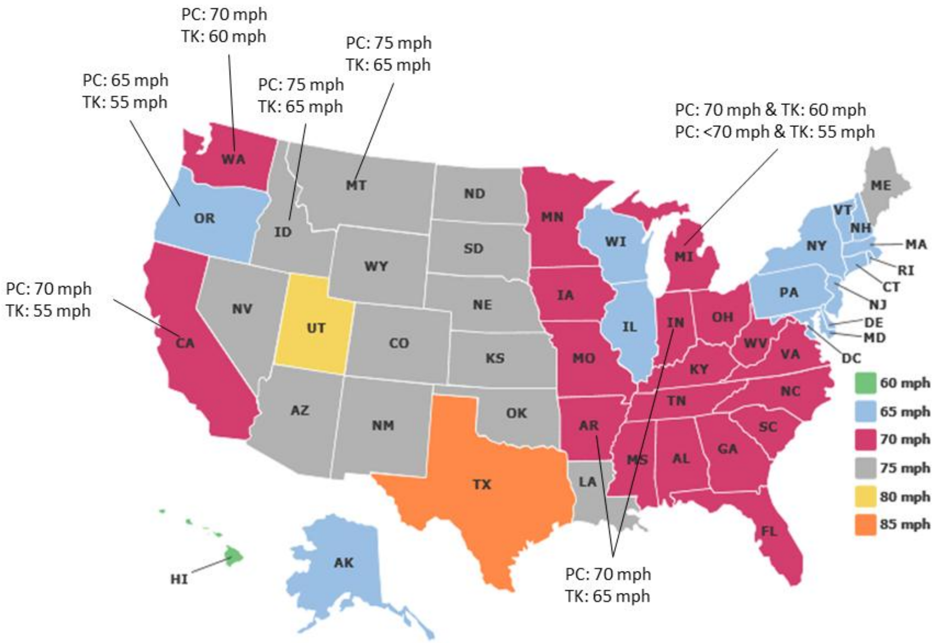


Figure 4. State Rural Interstate Posted Speed Limit Policies

Chapter 2
Literature Review

There have been a number of previous studies on the relationship between speed limit policies and highway safety. [3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15] The prior research has not reached a consistent conclusion on DSL's safety effects. For instance, there has been no clear correlation between speed limits and crash rates in the previous research. In addition, the numerical differences in crash rates resulting from different speed limit policies were often found to be statistically insignificant.

The literature also gives several explanations for the difficulty in finding statistically significant effects that favor the DSL policy. This could be a law enforcement issue, where law enforcement leniency gives drivers too much latitude to choose their driving speed, disregarding the posted speed limits. This could also be due to the fact that many trucks have speed governors (for economic and safety reasons) that control the maximum speed limit for these trucks.

The following literature review is organized into two subsections. The first describes previous research conducted in Idaho, which is then followed by a summary of research conducted nationwide.

Idaho Study

The researchers authoring this report conducted a study to examine the speed characteristics before and after enacting the Idaho DSL law in July 1998. This study investigated the DSL safety effects by examining the speed measurements from 17 locations on Idaho interstate highways. It was found that, for passenger vehicles, mean speed and 85th percentile speed increases were statistically significant, but they were only slight increases from a practical standpoint. For trucks, the mean speed and 85th percentile speed declined in a statistically significant way, but, again, in relatively small values. In addition the study also found truck speeds only reduced from 72 mph to 71 mph, which explains the finding that the percentage of trucks exceeding the speed limit on rural freeways doubled from 10 to 20 percent after enacting the DSL policy.[3]

Other Studies

After passage of the STURAA, many researchers evaluated the consequences of changing the speed limits. The following discussions summarize the main research work done in this field.

Freedman and Williams conducted a study using data extracted from 11 northeastern states to study the effect of keeping a speed limit of 55 mph, raising the speed limit to 65 mph, or enacting a DSL 65/55 mph. They examined variations in the mean and 85th percentile speed because it is an important descriptive statistic in evaluating road safety. They found that tractor-semitrailer speeds in states with differential speed limits were not significantly different from states with a 55 mph limit for all types of vehicles, and they found speeds to be three to six mph lower than states with 65 mph for all types of vehicles. They also found that generally there is no greater speed variance at higher speed limits.[4] Harkey and Mera studied whether DSL or USL is more beneficial to the traffic operation and transportation safety on interstate highways. Authors in this study used collected data from 12 states. They divided these states into four groups, based on implemented speed limits as follows: 55/55 (Pennsylvania), 65/55 (Illinois, Oregon, and Virginia), 65/60 (Indiana and Washington), 65/65 (Iowa, Idaho, and North Carolina). They concluded that a five mph differential speed between passenger cars and trucks did not affect the mean travel speeds of trucks and passenger cars. The scope for this research did not include identifying an underlying cause. Truck non-compliance rate significantly increased for the 65/55 (89.4 percent) and 65/60 (76.5 percent) groups compared to that in the 65/65 group (35.6 percent). They defined vehicles exceeding the speed limit by more than 5 mph as driving excessive speeds. They found that the number of vehicles driving at excessive speeds decreased. They also found that crash rates were higher in USL states for all crash types but the difference was not statistically significant.[5]

Wilmot and Khanal reviewed the results of forty one different studies performed in different states on the effect of differential speed limits on both safety and speed. They concluded that, generally, drivers select their desired speed as the speed they think would be safe, regardless of the posted speed limits. They also concluded that, generally, there is no evidence that DSL on highways has any positive impact on crash rates.[6]

Khan and Sinha evaluated the effects of changing the speed limit in the state of Indiana from a USL of 55 mph to a DSL of (65/60). They concluded that the policy change did not have a significant impact on crash and fatality rates. The research did not produce any diagnostics for this conclusion.[7]

Garber and Yuan studied the effect of DSL on both vehicle speeds and crashes for the period of the 1990's by comparing accident data of different states. These states were divided into four different groups: states that maintained a USL (Arizona, Missouri, and North Carolina), states that maintained DSL (Washington), states that changed from USL to DSL (Arkansas and Idaho), and states that changed from DSL to USL (Virginia). During this time period, some states switched from DSL to USL or USL to DSL. Data were collected during implementation of both policies and were included in their research. Five measures of effectiveness were calculated including the following: mean speed, speed variance, 85th percentile, speed median, and speed non-compliance. This research found that states with a USL experienced an increase in total and rear-end crash rates, which includes truck-involved crashes. It was also found that these states experienced an increase in the number of truck-involved crashes. However, there was no clear relationship between speed limits and crash rate to prove or disprove the hypothesis that DSL increases safety on interstate highways.[8] In addition, Garber and Ehrhart found that changes in crash rates did not result from individual effects. Instead, the changes were caused by a combination of individual effects like changing speed magnitudes, speed variation, and changing traffic volumes.[9]

Garber, Miller, Yuan, and Sun conducted a study for the Federal Highway Administration to determine the safety effects of USL and DSL on rural interstate highways for the period of 1991 to 2000 using crash data from 9 different states. These states were divided into four different groups: states that maintained a USL (Arizona, Missouri, and North Carolina), states that maintained DSL (Washington), states that changed from USL to DSL (Arkansas and Idaho), and states that changed from DSL to USL (Virginia). Five measures of effectiveness were studied for the speed data extracted from these states, including mean speed, variance, 85th percentile, median, and non-compliance. They also evaluated six types of crash rates including total crashes, fatal crashes, rear-end crashes, truck-involved crashes, fatal truck-involved crashes, and truck-involved rear-end crashes. Using the Empirical Bayes (EB) before-and-after method, it was found that there was no consistent variation of crash rates with respect to changes in the speed limit. It was also found that mean speed, 85th percentile speed, median speed, and crash rates showed an increasing trend regardless of the speed limit policy.(10)

Cirillo(11) and Spencer(12) suggested that enacting a DSL would be an unsafe act, because a significant percentage of traffic would have much lower speeds than general traffic. This speed differential would require frequent lane changing and passing to avoid crashes. Cirillo(11) further stated that accident and fatality rates on interstate highways are two to five times less than the non-interstate highways, providing little justification for the DSL safety measure.

Garber and Gadiraju, conducted a simulation experiment to study the safety impact of DSL, and restricting the tucks in the right lane. The result concluded that there are no safety benefits from the implementation of DSL, and lane restriction of trucks. They also indicated that these strategies would increase the interaction between trucks and automobiles, and so would increase crash potential. They recommended a uniform speed limit of 65 mph to reduce the trucks-automobiles interaction. (13)

Garber and Gadiraju, followed their simulation study with another study in which they studied the effect of increasing the speed limit from 55/55 to 65/55 mph on speed and crashes. Regarding the speed, it was found that after increasing the passenger car speed limit by 10 mph, the overall average speed increased by 3.6 mph while the 85th percentile speed increased by five mph. Regarding the speed variance, it was also found that increasing the speed limit by 10 mph for passenger cars, decreased the speed variance for these passenger cars. They explained that this might be because the new 65 mph speed limit is closer to the design speed. When the authors compared the speed variance for all vehicles (passenger cars and trucks), it was noticed that speed variance was significantly higher than the speed variance in neighboring West Virginia, which increased speed limits from 55/55 to 65/65 mph. This showed them that enacting DSL will likely increase the overall speed variance. When studying the effect of this passenger car speed limit increase on the fatalities, it was found that fatalities increased by 43.2 %. They stated that some of this increase might be because of some other factors like weather or traffic volumes.(14)

Johnson and Pawar performed a cost-benefit analysis to cover the financial topics related to maximum truck speeds.(15) To perform this task, the authors surveyed stakeholders like truck drivers, trucking company safety and operations personnel, and truck manufacturers. The authors also collected speed data from rural interstate highways (I-44, Cherokee Turnpike in Oklahoma, I-40 Arkansas, and I-57 in Illinois). Speed data were divided into four different speed-limit groups as follows: 75 mph USL (Oklahoma), 70 mph USL (Missouri), 70/65 DSL (Arkansas), and 65/55 DSL (Illinois). The authors in this study concluded that, regardless of the 10 mph difference in posted speed limits, mean speeds differed only by 1.6 mph, which supports previous literature that drivers choose speeds they think are safe and comfortable regardless of the posted speed limit. They also reported that, due to the fact that most commercial trucks have speed governors, average speeds for trucks were three to four mph lower than passenger vehicles for areas with USL. The corresponding difference for DSL areas was 9 mph for a 10 mph differential and 7 mph for a 5 mph differential.

The literature shows no consistent conclusion regarding the safety effects of DSL. More specifically, there is no clear correlation between variations in posted speed limit policies and crash rates. In addition, different authors found that even if there is a numerical difference in crash rates between two policies, these crash rate differences are not statistically significant.

Table 1. DSL Effects on Crash Rates

Paper / Report	Conclusion	States
Cirillo (2003)	DSL creates an unsafe situation in which a significant percentage of traffic is operating much slower than general traffic.	"20 State Highway Departments, including Ohio"
Spencer (2003)	DSL increases safety concerns on highways because it forces vehicles to be constantly in conflict with each other.	Ohio
Yuan and Garber (2002)	-No significant increase was observed in truck-involved rear end crash rate for the third group (uniform to differential limits). -States that changed from differential to uniform limits experienced an increase in total crash rate.	Group 1, maintained USL: Arizona, Iowa, and North Carolina; Group 2, maintained DSL: Illinois, Indiana, and Washington; Group 3, changed from USL to DSL: Arkansas, and Idaho; Group 4, changed from DSL to USL: Virginia
Harkey and Mera (1994)	-Higher proportion of automobile-into truck and truck-into-automobile crashes occurred in uniform speed limit states. The exception was the rear-end crashes, where more automobile-into-truck collisions occurred in the differential limit group. -Truck-into-automobile sideswipe accidents in differential limit states were much lower compared to those in uniform limit states.	65/ 55 mph group: Virginia, Illinois, California, and Oregon; 65/ 60 mph group: Indiana, Missouri, and Washington; 65/65 mph group: North Carolina, Iowa, Arizona, and Idaho
Garber, Miller, Yuan and Sun (2003)	There was no consistent trend in crash rates matching the changes in speed limits.	Group 1, maintained USL: Arizona, Iowa, and North Carolina; Group 2, maintained DSL: Illinois, Indiana, and Washington; Group 3, changed from USL to DSL: Arkansas, and Idaho; Group 4, changed from DSL to USL: Virginia
Garber and Gadiraju (1990)	DSL increased the interactions between automobiles and trucks and therefore the potential for accidents particularly on highways with high volume and percentage of trucks.	Computer simulation work
Garber and Gadiraju (1991)	10 mph differential speed limit increased the average speed with 3.6 mph, and the 85th percentile speed with 5 mph. DSL also increased the overall speed variance, and negatively impacted fatalities.	Virginia
Freedman, F and A.F. Williams (1992)	For passenger cars, for DSL states, mean and 85th percentile speeds are not significantly different from 65 mph USL states, while there was a significant different to the 55 mph USL states.	Connecticut, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, New Hampshire, Ohio, Vermont, Virginia, and West Virginia
Wilmot, G. C. and M. Khanal (1999)	Generally, there is no evidence that DSL on highways has any positive impact on crash rates.	Review book for lots of other studies
Khan, N. M., and K. C. Sinha (2001)	5 mph DSL did not have a significant impact on crash and fatality rates.	Indiana
Johnson, S. L. and N. Pawar (2005)	10 mph DSL would not produce a 10 mph difference in the average speed of automobiles and trucks. Even under USL, average speed of trucks is lower than that of automobiles with three to four mph	Oklahoma, Missouri, Arkansas, and Illinois

Previous research identified in Table 1 and other literature referenced in this document found that overall speeds tended to increase when adding or increasing the DSL. However, research also found that DSL also produced larger truck speed variances. For different types of crash rates, previous research arrived at varying conclusions and Table 1 provides a summary. However, this literature review found that rear-end crashes tended to increase. Researchers reasoned that this increase was due to higher speed variances. Overall, the body of research reported varying results in terms of statistical significance of the difference in crash rates observed before and after DSL implementation.

Chapter 3
Data Description

Speed Data

There are 522 miles of rural interstate highway in Idaho. Speed and volume data were collected at Automated Traffic Recording (ATR) stations on these freeways. Individual vehicle speeds from three ATR stations were available from January 1996 to May 1998, and this increased to at least 16 ATR stations from May 1998 to the present.

Figure 5 Interstate Highways in Idaho.[12]

ATR data from 2007 showed that the lowest volume site was ATR 73 on I-15, with 1,017,007 total recorded speeds (312,747 truck speeds). This equates to an average of about 26,000 truck speeds per month. Speed data were filtered so that speed records less than 45 mph and greater than 100 mph were excluded. This filtering excluded 50,000 data points out of 70,000,000 data points. In addition, to exclude any severe seasonal effects like snow and ice, only data for the months of May and June were included. Additional months were not necessary, because of the large sample size present for any given month. This study gathered May and June speeds from 1996 to 1998 and compared them to the speeds collected for the same months in the years 2009 to 2011.

Idaho Transportation Department's (ITD) ATR data classifies vehicles by length, not by axles. Based on Federal Highway Administration vehicle classifications, five-axle trucks have lengths greater than 40 ft, which is consistent with ITD's ATR vehicle classification scheme. As a result, an accurate categorization was to use lengths less than or equal to 23 ft to identify passenger vehicles and lengths exceeding 40 ft to identify trucks affected by the DSL policy. Vehicle sizes between 23 ft and 40 ft were excluded from the speed data, because they are not passenger vehicles and are not subject the DSL policy. Crash data did not employ this exclusion. However, the definition for trucks was still consistent with those affected by the DSL policy.

Crash Data

Crash data were obtained from ITD's Office of Highway Safety (OHS), for the period starting at 1991 until 2011. Five crash types were used in the analysis of this study and they are as follows:

- Total crashes
- Total fatal crashes
- Total fatal truck-involved crashes (truck-only and with passenger vehicles)
- Total rear-end crashes (including both truck or passenger vehicle being the leading vehicle)
- Total truck-involved rear-end crashes (including both truck or passenger vehicle being the leading vehicle)

Data were then divided into three main time periods:

1. Period 1: January 1, 1992 - April 11, 1996 (with a uniform speed limit of 65 mph)
2. Period 2: April 12, 1996 - June 30, 1998 (with a uniform speed limit of 75 mph)
3. Period 3: July 1, 1998 – December 31, 2011 (with a differential speed limit of 75 mph for passenger cars and 65 mph for commercial truck vehicles)

Traffic Flow and Geometric Data

Average Annual Daily Traffic (AADT) data were reviewed for all interstates from 1992 to 2011. These data included route name, segment location, passenger vehicle AADT, truck AADT, and total AADT. Vehicle Miles Traveled (VMT) was calculated based on AADT and the segment length. Geometric data included the number of lanes, lane width, shoulder width, and whether or not rumble strips were present.

The AADT data were used to control for changes in traffic volumes during the study period and to calculate crash rates. The geometric data were used to control for different highway design features that could plausibly affect crash statistics.

Crash rates were calculated for each segment using the segment's crash frequency obtained from ITD's OHS and the same segment's length and AADT, also obtained from ITD.

Chapter 4
Data Analysis Findings

Analysis Overview

We analyzed the speed and crash data described in the previous section to assess the impact of Idaho's DSL policy on highway safety. More specifically, we sought to answer the following three questions:

- What impact has Idaho's DSL policy had on truck speeds and speed differences between trucks and passenger vehicles?
- What impact has the DSL policy had on crash rates in Idaho?
- To what degree have the highway characteristics of Idaho's roads, such as installation of rumble strips, contributed to the changes in crash rates observed in the study period?

Speed Analysis

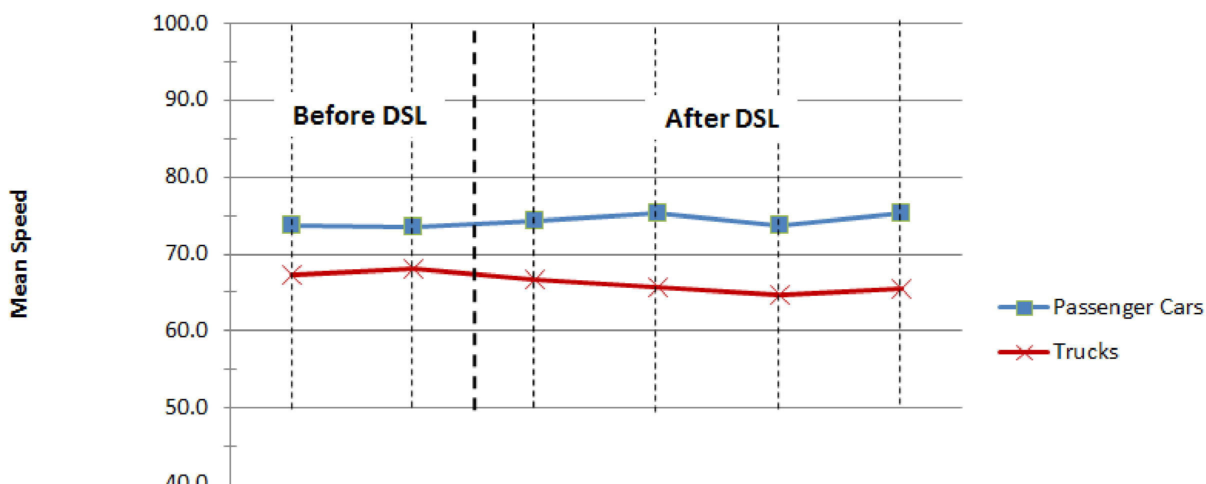
Speeds can vary for several reasons, such as road surface conditions, traffic volumes, highway geometry, and roadside conditions. For this reason, it is important to control for varying conditions before and after the DSL policy implementation. This analysis isolates the DSL policy's effect on speeds by making several speed comparisons. These comparisons relate speeds before to speeds after the Idaho DSL policy was adopted. The comparisons measure the policy's long-term impact on Idaho driving behavior in terms of the mean driving speed as well as variations in driving speed.

Implementing the DSL policy correlates with reduced truck speeds, where truck speeds reduced from an average of 67.7 mph to 65.6 mph. At the same time, passenger car speeds increased from 73.6 mph to 74.7 mph. These speed changes are statistically significant with at least a 95 percent probability. The following discussion analyzes the before-and-after speed data in more detail, where the discussion is divided into four subsections, as follows:

1. Long-term impact of the DSL on Idaho driving behavior
2. Speed trends
3. Pace analysis
4. Speed compliance/non-compliance

Long-Term Impact on Idaho Driving Behavior

Prior to implementation of DSL on Idaho's rural interstates, the mean truck speeds were 5.9 mph less than passenger vehicles. Figure 6 illustrates that the difference in the average speed driven by trucks and other vehicles increased to 9.1 mph after DSL implementation. This increased difference from before-DSL to after-DSL was two-sided, where passenger vehicle speeds increased 1.1 mph (73.6 mph to 74.7 mph) and truck speeds decreased 2.1 mph (67.7 mph to 65.6 mph).

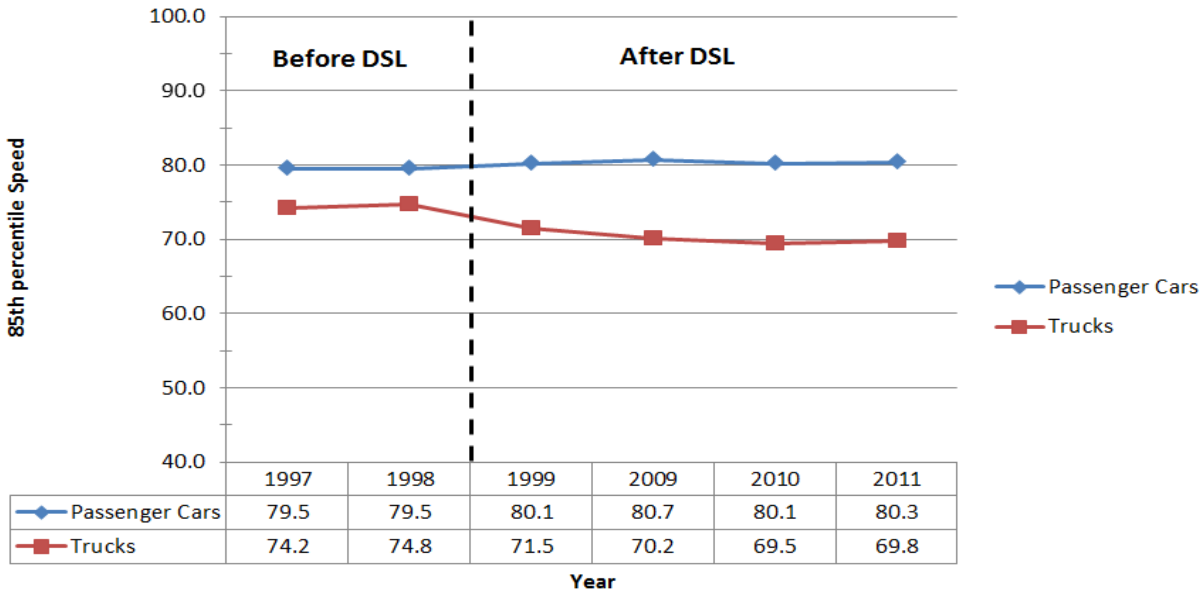


	1997	1998	1999	2009	2010	2011
Passenger Cars	73.8	73.5	74.4	75.4	73.7	75.3
Trucks	67.4	68.1	66.6	65.6	64.6	65.5

Year

Figure 6. Idaho Rural Interstate Before-After Passenger Vehicle and Large Truck Mean Speeds

The 85th percentile speed is the speed at or below which 85 percent of vehicles travel. Figure 7 compares the 85th percentile speeds for trucks and other vehicles, and shows that the 85th percentile speed for trucks declined by 4.5 mph. The truck 85th percentile speed is closer to the truck mean speed, now within 5 mph, compared to 7.5 mph before the 1998 DSL policy enactment. However, the passenger vehicle 85th percentile speed slightly increased by approximately the same amount as the passenger vehicle mean speed, suggesting a unilateral upward shift in passenger vehicle speeds. As a result, DSL implementation does correlate with reduced truck speeds and truck speed variability.



	1997	1998	1999	2009	2010	2011
Passenger Cars	79.5	79.5	80.1	80.7	80.1	80.3
Trucks	74.2	74.8	71.5	70.2	69.5	69.8

Figure 7. Idaho Rural Interstate Before-After Passenger Vehicle and Large Truck 85th Percentile Speeds

Speed Trends

Since the DSL policy implementation, Idaho's speed trends have stabilized. Figure 6 and Figure 7 demonstrate this by the fact that there is no sizable decline in speed data shown for the years 2009 to 2011.

The stabilized mean passenger vehicle and truck speeds in Idaho are 74.7 and 65.6 mph, respectively (see Figure 6). The passenger vehicle and truck mean speeds are very close to their respective posted speed limits. In addition, Figure 7 shows that the 85th percentile speeds have stabilized at about 5 mph above the respective speed limits for passenger vehicles and for trucks. This shows that passenger car drivers and truck drivers chose more similar speeds relative to their respective speed limits after implementing the DSL policy in Idaho. The following section on speed limit compliance addresses this observation in more detail.

Pace Analysis

The pace speed is the 10 mph range that includes the most observed vehicle speeds. In 1997, before the DSL policy in Idaho, the truck pace speed was 63 mph to 72 mph. Of all the speeds recorded, 58 percent were in this range. The proportion of truck speeds within the pace range is a measure of speed variability (i.e., the greater the percentage within the pace the lower the speed variability).

After the policy was implemented, the truck pace speed decreased 2 mph to a range of 61 mph to 70 mph, with 74 percent falling in this range. Truck speed variability reduced considerably after the DSL implementation. These two points of evidence, related to the 85th percentile and the pace speeds, support the observation that the DSL policy does favorably impact truck driver behavior by reducing the more extreme truck speeds. It is worth noting that some trucking companies employ speed governors in an effort to limit truck speed and improve fuel efficiency. The use of speed governors may also have contributed to the reduction observed in truck speed variability. However, speed governor usage data were not available and as a result, we were unable to ascertain how much of the change was due to the DSL policy or speed governors.

Another point to emphasize here is that actual driving speeds vary from the posted speed limit. The 85th percentile and pace speeds illustrate this fact very well. Before the DSL policy, 85 percent of speeds were equal to or lower than 79.5 mph and 74.5 mph, for passenger vehicles and trucks respectively. Despite the uniform 75 mph posted speed limit, 15 percent of passenger vehicles were exceeding the speed limit by at least 4.5 mph. A similar statement could be made for trucks, where 15 percent of trucks were driving at or above the speed limit. The posted speed limit does impact the speeds, but many drivers will still choose to exceed posted speed limits. This observation holds for vehicle speeds after DSL implementation too, where 15 percent of truck speeds exceeded the new 65 mph speed limit by 5 mph or more.

Speed Compliance and Non-Compliance

Speeds at or below the speed limit are compliant and those exceeding the speed limit are in violation or non-compliant. Because speeds vary, the degree to which speeds violate the speed limit also varies. To capture changes in speed limit compliance, speeds were grouped into four categories:

- At or below the speed limit
- Exceeding the speed limit by up to 5 mph
- Exceeding the speed limit from 5 to 10 mph
- Exceeding the speed limit by more than 10 mph

As can be seen in Figure 8 and Figure 9, the before- and after-DSL compliance changed for both passenger vehicles and commercial trucks. Passenger vehicle compliance slightly worsened, while truck compliance improved. For passenger vehicles, there was a general shift of speeds from less than the speed limit to the middle two categories. However, implementation of the DSL visibly affected truck speed limit compliance. Figure 9 shows an overall trend of reduced truck speeds, where truck speeds tended to group around the new 65 mph speed limit. This is shown by the percentage of truck speeds at or below the speed limit, increasing from about 33 percent to about 43 percent and the percentage of truck speeds up to 5 mph over the speed limit increasing from 31 percent to 41 percent. In addition, the percentage of truck speeds in excess of 15 mph over the speed limit decreased from 13 percent to about four percent. As a result, the DSL policy correlates with improved truck speed compliance.

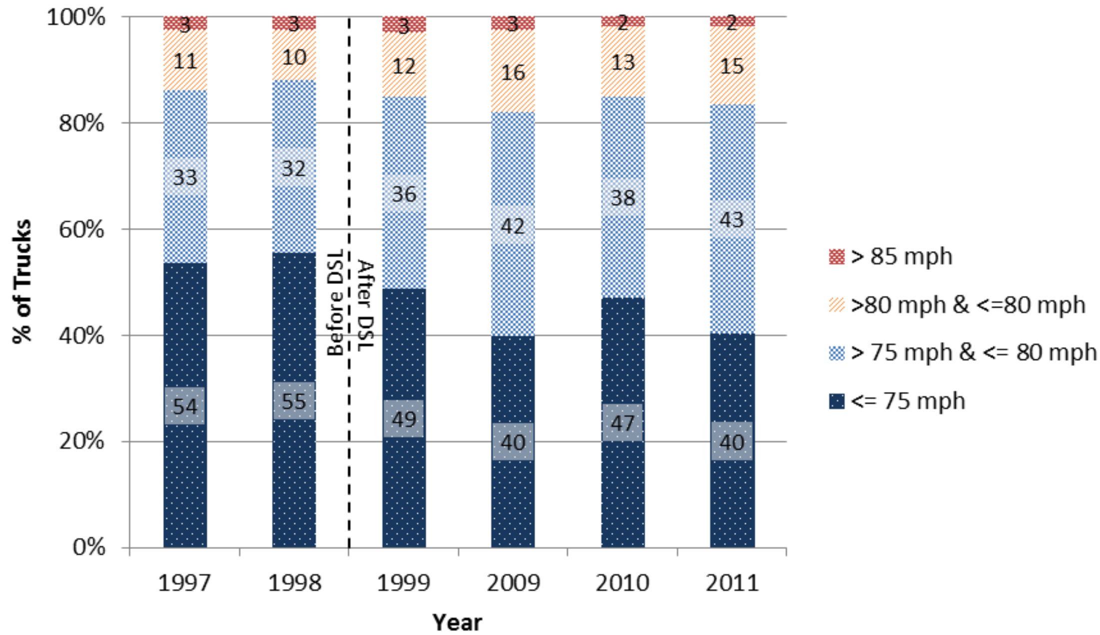


Figure 8. Idaho Rural Interstate Speed Limit Passenger Vehicle Compliance / Non-Compliance

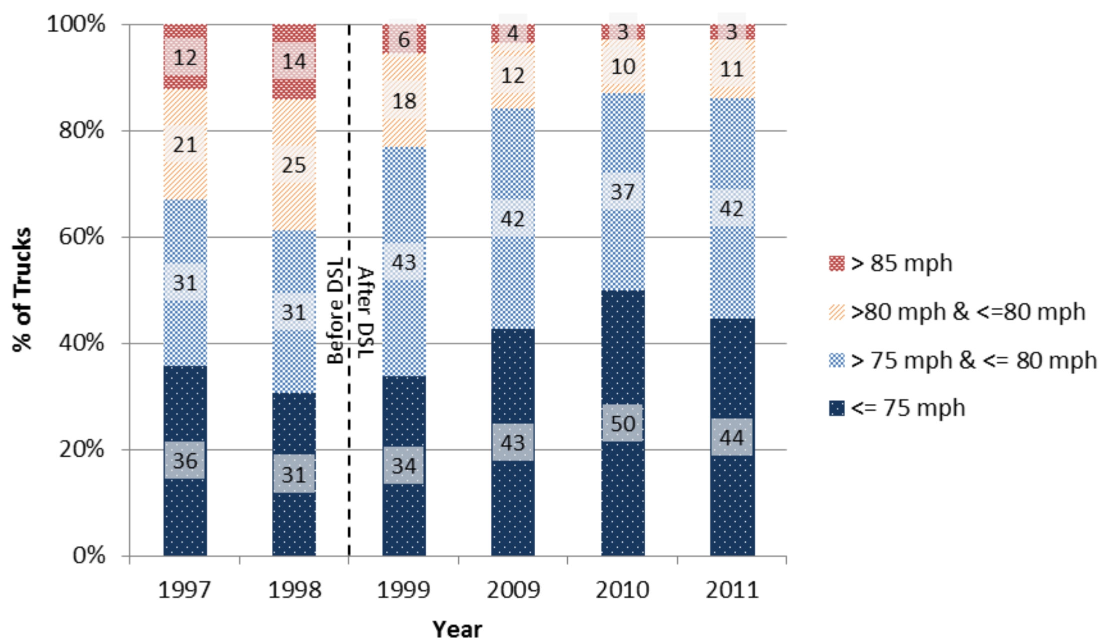


Figure 9. Idaho Rural Interstate Speed Limit Truck Compliance / Non-Compliance

Crash Analysis

Crash rates, in crashes per million vehicle miles, were calculated using the following equation:

$$Annual\ Crash\ Rate = \frac{\text{Crash Frequency} * 1{,}000{,}000}{\text{AADT} * 365 * \text{Segment Length}}$$

Figure 10. Crash Rate Equation

Figure 11 compares VMT to all-vehicles and truck-involved crash rates, while Figure **12** shows all-vehicles fatal, truck-involved fatal, all-vehicles rear-end, and truck-involved rear-end crash rates. As can be seen in these figures, VMT steadily grew during the study period. The crash rates before enacting the DSL fluctuated widely with high peaks in 1995 and 1997. After enacting the DSL in 1998, fluctuation subsided revealing a generally declining trend with low values in 2010 and 2011. The Figure 11 shows that crash rates for all-vehicles declined from an average value of 0.92 to 0.68 per million vehicle miles traveled since the DSL law was established. For the same two time periods, truck-involved crash rates declined from an average value of 0.57 to 0.36 per million vehicle miles traveled. This represents a 26% and 38% crash rate reduction for all-vehicle crashes and for truck-involved crashes, respectively, showing a more pronounced downward trend for trucks.

In addition to the DSL policy, other factors may have contributed to the declining crash rate trend. For instance, safety improvements such as installation of rumble strips contributed to the decline in crashes. In addition, new safety devices in newer vehicles like ABS brakes may have played a role in the crash reduction observed. Fluctuating trends in the mid-nineties might be due to large speed variations occurring because of speed limit changes in 1996 and 1998. Johnson and Pawar mentioned that the period after each speed limit increase could be divided into two periods. The first period is the "Transition Period," in which drivers increase speed gradually, while the second period is called the "Adaptation Period," in which drivers adapt to the new increased speed.[15] The speed adjustments result in larger speed variances soon after the adjustment because some drivers will maintain the old speed limit and other drivers prefer to drive the new higher speed limit. This may explain the large crash rate variations in 1995 and 1997.

Due to the fact that AADT is directly correlated to VMT, crash rates yielded the same trends relative to AADT as those shown for VMT. As a result, crash rate trends with respect to AADT are not discussed any further in this report.

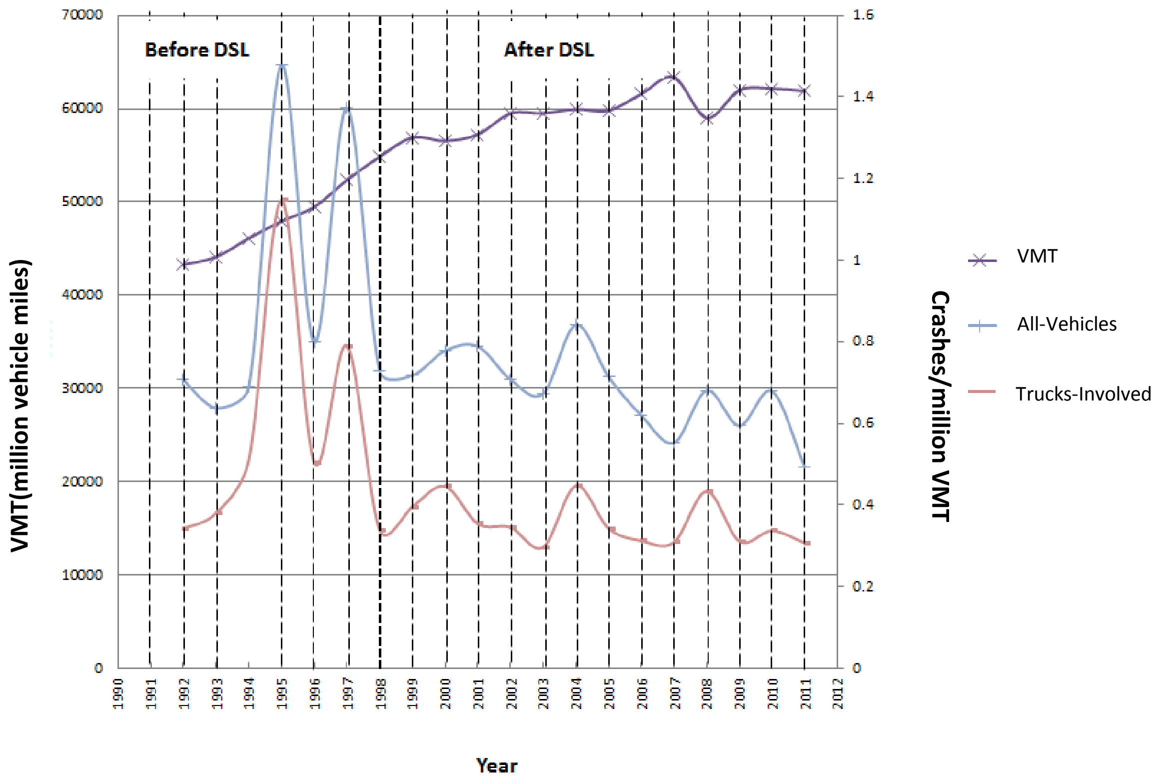


Figure 11. VMT verses Crash Rates for All Vehicles Total Crashes, and Trucks Total Crashes on Rural Idaho Interstates

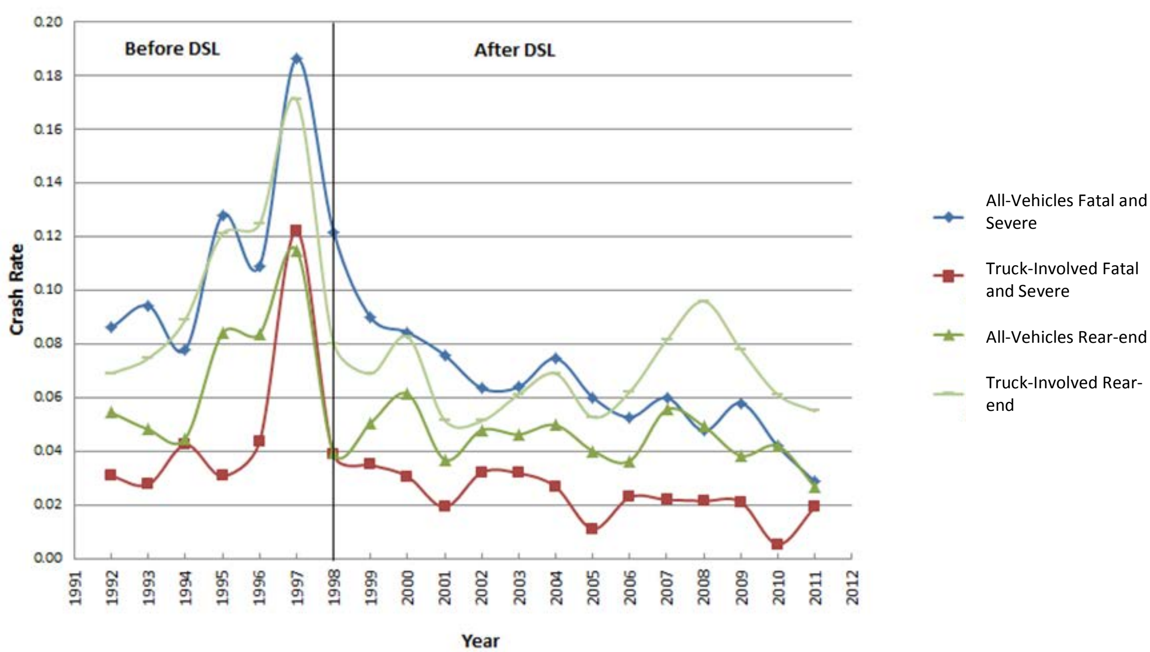


Figure 12. Crash Rates for All-Vehicles Fatal and Severe, Truck-Involved Fatal and Severe, All-Vehicles Rear-end, and Truck-Involved Rear-end on Rural Idaho Interstates

One common hypothesis of traffic engineers and researchers is that the number of crashes increases as AADT and VMT increases. However, as shown in Figures 13-15, this is not necessarily true. Figure **13** compares fatal crashes and VMT in Oregon and Figure **14** and Figure **15** show the national trend. These trends are consistent with the Idaho crash rate trend shown in Figure 11 and Figure **12**.

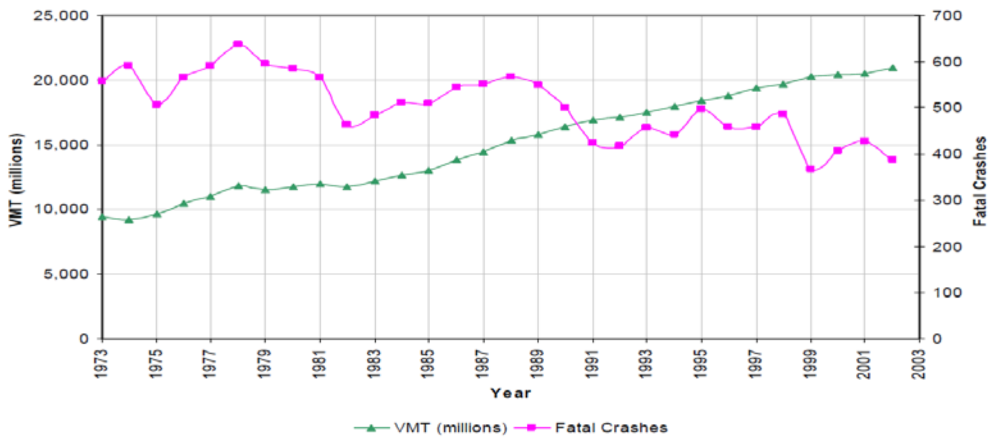


Figure 13. Total Fatal Crashes and Vehicle Miles Traveled, Oregon (1973-2002)(2)

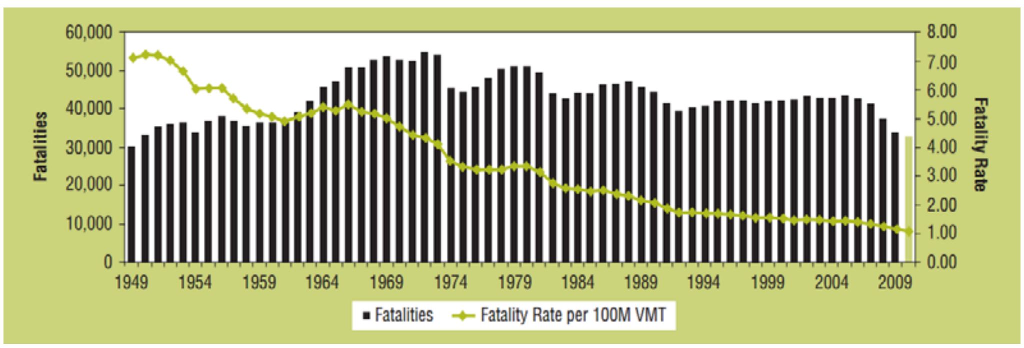


Figure 14. National Fatalities and Fatality Rate per 100 Million VMT by Year(13)

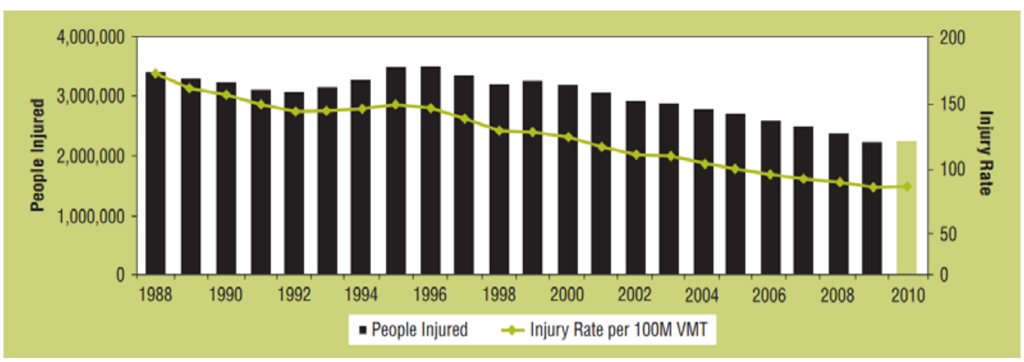


Figure 15. National Injuries and Injury Rate per 100 Million VMT by Year(13)

Table 2 shows crash rates per million VMT for truck-involved crashes and total crashes. As seen in this table, truck-involved crash rates increased from 0.807 crashes per million VMT to 0.855 crashes per million VMT when the speed limit was increased from 65 to 75 mph. Following implementation of the DSL policy, which lowered the truck speed limit back to 65 mph, the average truck-involved crash rate dropped to 0.549 crashes per million VMT. Crash rates for all vehicles followed a similar trend. The data in Table 2 also show the safety benefits of installing rumble strips on interstates in terms of truck-involved crash rates.

Table 2. Total Crash Rate for All Vehicles and Trucks

	Period 1[a]			Period 2[b]			Period 3[c]					
							Rumble Strips			No Rumble Strips		
	Average	**SD**	**N[d]**	**Average**	**SD**	**N[d]**	**Average**	**SD**	**N[d]**	**Average**	**SD**	**N[d]**
All Vehicles	0.881	0.846	388	1.123	0.747	193	0.696	0.501	888	0.783	0.529	371
Truck-Involved	0.807	0.823	368	0.855	0.687	179	0.481	0.357	878	0.549	0.411	367

a. Speed limit of 65 mph and No DSL.
b. Speed limit of 75 mph and No DSL.
c. DSL (75/65 mph).
d. Sample Size

Table 3 shows fatal and severe injury crash rates for all vehicles and for truck-involved. As can be seen in this table, average fatal and severe injury crash rates for all vehicles and for truck-involved were highest during Period 2, with a USL of 75 mph. Then in Period 3, where DSL was employed, crash rates decreased, below the Period 1 crash rate. While it is difficult to explain the Period 2 peak in crash rates, it appears that DSL, among other factors, increases safety on rural interstates. Speed governors and improved vehicle design are other possible contributing factors.

Table 3 also demonstrates the benefits of installing rumble strips on the interstates. Following installation of rumble strips, the average annual fatal and severe crash rates for all vehicles reduced from 0.0886 to 0.0560 in Period 3, and also reduced fatal and severe injury crashes for truck-involved crashes declined from 0.0097 to 0.0062 in Period 3.

Table 3. Fatal and Severe-Injury Crashes for All vehicles and Trucks

	Period 1[a]			Period 2[b]			Period 3[c]					
							Rumble Strips			No Rumble Strips		
	Average	SD	N[d]	Average	SD	N[d]	Average	SD	N[d]	Average	SD	N[d]
All Vehicles	0.143	0.123	372	0.208	0.129	171	0.095	0.072	868	0.128	0.106	363
Truck-Involved	0.225	0.131	160	0.400	0.226	70	0.183	0.104	650	0.238	0.152	273

a. Speed limit of 65 mph & No DSL.
b. Speed limit of 75 mph and No DSL.
c. DSL (75/65 mph).
d. Sample Size

Table 4 shows rear-end crashes for all vehicles and for truck-involved. Rear-end crashes followed a similar trend to fatal and severe crashes by having the highest values during Period 2 then declining below the Period 1 rates during Period 3. One of the largest reductions was from Period 2 to Period 3, with rates of 0.165 and 0.105, respectively. This gave a crash rate reduction of approximately 70 percent.

Table 4. Rear-End Crashes for All Vehicles and Trucks

	Period 1[a]			Period 2[b]			Period 3[c]					
							Rumble Strips			No Rumble Strips		
	Average	SD	N[d]	Average	SD	N[d]	Average	SD	N[d]	Average	SD	N[d]
All Vehicles	0.128	0.122	308	0.165	0.152	156	0.091	0.088	868	0.105	0.105	363
Truck-Involved	0.381	0.361	220	0.412	0.301	110	0.243	0.211	788	0.305	0.316	331

a. Speed limit of 65 mph & No DSL.
b. Speed limit of 75 mph and No DSL.
c. DSL (75/65 mph).
d. Sample Size

The Empirical Bayes (EB) method can overcome the limitations of other before-and-after crash analysis by accounting for the regression-to-the-mean effect. It also accounts for changes in traffic volume as well as factors such as changes in the crash reporting practices and the driving environment. To estimate the expected number of truck-involved crashes during the after-period without treatment (if DSL were not implemented), two trends are considered with the EB method:

1. The crash trend at the treatment site prior to the DSL implementation (April 15, 1996 to June 30, 1998)
2. The crash trends at similar sites (control sites) during the analysis period. For this analysis, the trend of passenger vehicle crashes (July 1998 to December 2011) was used as a control group for truck-involved crashes during the same time period. The assumption here is that changes in the driving environment, enforcement level, crash reporting, etc., would impact both passenger vehicles and trucks in a similar way.

The crash trend at the sites prior to the DSL implementation (from April 14, 1996 to June 30, 1998) was used to estimate the expected number of truck-involved crashes at the sites during the after-period had the DSL not been implemented. A statistical model was developed for modeling the safety performance function (SPF) at control sites. The SPF is a mathematical model that relates the dependent variable (crash frequency of a roadway section) to independent variables, such as traffic volume. Literature shows that the Poisson and the Negative Binomial (NB) regression models have been extensively studied and developed for crash data analysis. Presently it is common to assume that the crash data come from a NB distribution. As a result, the NB distribution was used to develop the SPF model for this research.

In this study, a generalized linear modeling (GLM) approach was used to develop the SPF. The GLM procedure allows the specification of a NB distribution by fitting a generalized linear model to the data by maximum likelihood estimation of the parameters. The SPF used in this study is shown in Figure 16. The test of model effect results are shown in Table 5.

$$\mathrm{m} = L(e^{b_0 + b_1 \ln AADT})$$

where:

- m = mean expected number of truck-involved crashes per year for a specific roadway segment
- L= Length of roadway segment
- AADT = Average Annual Daily Traffic (vehicle/day)
- b_0 = model intercepts
- b_1 = regression coefficient

Figure 16. SPF Equation

Table 5. SPF Test of Model Effect

Source	Parameter Value	Wald Chi-Square	df	Sig.
b_o	-1.89	47.424	1	.000
b_1	0.14	209.106	58	.000

The prediction model developed was used, along with the EB method procedures outlined by the U.S. Department of Transportation (USDOT), to determine the safety impacts of DSL implementation based on Idaho's crash experience.[14] Because most of the sites did not have shoulder rumble strips installed during the before period (1996-1998), only sites that did not have shoulder rumble strips installed during the after period (1998-2011) were included in the EB before and after analysis. The results showed that truck-involved crashes decreased by an estimated average value of 8.56 percent with a standard deviation of 5.06 percent after the implementation of the DSL. The 95 percent confidence interval for the change in truck-involved crashes resulting from DSL implementation ranged from a reduction of 18.68 percent to a marginal increase of 1.56 percent. For Idaho, this suggests that policy makers can be confident that the DSL policy contributes to favorable safety trends.

Chapter 5
Conclusions and Recommendations

In this research, an evaluation of the impacts of differential speed limits on rural interstate highways in Idaho was completed. The main purpose for this research was to determine if there were any speed or safety effects after enacting the DSL. Regarding the effects of DSL on speed, it was found that passenger car and truck speeds stabilized since the DSL policy implementation date. More specifically, the DSL policy correlated with reduced a truck mean speed of 65.6 mph and less variability. In addition, DSL may also have contributed to increased speed limit compliance.

DSL favorably affects safety. Highways experienced higher crash rates prior to DSL implementation. In addition to DSL's speed influence, this demonstrates DSL's influence towards improving vehicle safety on rural freeway segments. The difference in speeds caused by Idaho's DSL policy did have the potential to increase crash rates, but it appears that the opposite is true. However, other factors, such as more sophisticated braking systems and improved highway design, may also have acted to reduce the Idaho crash rates. This research was only able to control for highway design improvements. Based on the statistical analysis of speeds, different crash types, and the Empirical Bayes method analysis, the data strongly suggest that the type of influence a DSL policy has improves traffic safety.

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