U.S. Department of Transportation
National Highway Traffic Safety Administration

NHTSA

Preliminary Regulatory Impact Analysis
And Initial Regulatory Flexibility Analysis

FMVSS No. 140
Speed Limiting Devices

Office of Regulatory Analysis and Evaluation
National Center for Statistics and Analysis

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EXECUTIVE SUMMARY

On September 8, 2006, Road Safe America and a group of nine motor carriers (Schneider National, Inc., C.R. England, Inc., H.O. Wolding, Inc., ATS Intermodal, LLC, DART Transit Company, J.B. Hunt Transport, Inc., U.S. Xpress, Inc., Covenant Transport, Inc., and Jet Express, Inc.) petitioned the Federal Motor Carrier Safety Administration (FMCSA) to require speed limiting devices[1] in vehicles with a GVWR greater than 11,793 kilograms (26,000 pounds) and that the devices be set at not more than 68 mph. They also requested that the requirements apply to all trucks manufactured after 1990.

On October 20, 2006, the American Trucking Associations (ATA) submitted a petition to the National Highway Traffic Safety Administration (NHTSA) requesting that the agency initiate rulemaking to amend the Federal motor vehicle safety standards to require vehicle manufacturers to install a device to limit the speed of trucks with a gross vehicle weight rating (GVWR) greater than 11,793 kilograms (26,000 pounds) to no more than 68 miles per hour (mph). The ATA claimed that reducing speed-related crashes involving trucks is critical to the safety mission of NHTSA, and that these new requirements are needed to reduce the number and severity of crashes involving large trucks.

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[1] The terms “speed limiting devices,” “speed limiting systems,” and “speed limiters” are used interchangeably throughout the PRIA and have the same meaning.

NHTSA granted these petitions to initiate a rulemaking to establish a safety standard to require devices that would limit the speed of certain heavy trucks.[2] NHTSA and FMCSA subsequently determined that they would engage in a single rulemaking activity because of the overlapping issues raised in the petitions to the agencies.

Performance Requirements:

NHTSA is proposing to establish a new Federal Motor Vehicle Safety Standard (FMVSS) that would require new multipurpose passenger vehicles, trucks, buses, and school buses with a gross vehicle weight rating of more than 11,793.4 kilograms (26,000 pounds) to be equipped with a speed limiting device that would be set to a maximum speed to be determined in a final rule implementing the proposal.

To determine compliance with the operational requirements for the speed limiting device (i.e., that the vehicle is in fact limited to a set speed), NHTSA is proposing a vehicle level test that involves accelerating the vehicle and monitoring the vehicle's speed. The proposed test procedure is substantially based on the United Nations Economic Commission for Europe (UNECE) R89, which is described in the NPRM.

Finally, to assist FMCSA's enforcement officials with post-installation inspections and investigations to ensure compliance with the requirement to maintain the speed limiting devices, NHTSA is proposing to require that the vehicle set speed and the speed determination parameters

[2] On January 26, 2007, the agencies issued a request for comments (72 FR 3904). See Docket No. NHTSA-2007-26851. On January 3, 2011, NHTSA granted the petitions (76 FR 78).

be readable through the On-Board Diagnostic (OBD) connection. In addition to the current speed limiting device settings, NHTSA is proposing that the previous two set speed and speed determination parameter modifications (i.e., the two most recent modifications of the set speed of the speed limiting device and the two most recent modifications of the speed determination parameters) be readable and include the time and date of the modifications.

FMCSA is proposing a Federal Motor Carrier Safety Regulation (FMCSR) requiring each commercial motor vehicle with a GVWR of more than 11,793.4 kilograms (26,000 pounds) to be equipped with a speed limiting device meeting the requirements of the proposed FMVSS applicable to the vehicle at the time of manufacture, including the requirement that the system be set to a particular speed. Motor carriers operating such vehicles in interstate commerce would be required to maintain the speed limiting systems for the service life of the vehicle.

We expect that, as a result of this joint rulemaking, all newly manufactured heavy vehicles would be limited to a particular speed or less at the time of first sale, and virtually all these vehicles would maintain the speed limiter settings though out the lifetime operation of the vehicle.[3]

[3] A typical NHTSA benefit and cost analysis considers what would occur during the operational life of a vehicle manufactured in a given model year (such a model year being after the rule takes full effect). In the analysis, the estimated costs and benefits are discounted at 3% and 7% since the benefit would occur throughout the operational life of a model year vehicle (and not necessarily in the year the vehicle is manufactured). Costs of equipment added to vehicles are not discounted since they are incurred when vehicles are manufactured and sold. However, this rule assumes an equipment cost of $0.

Benefits:

Speed limiters are likely to have three main safety effects. First, by reducing truck and bus travel speeds and thereby reducing the kinetic energy of trucks or buses striking other vehicles, speed limiters are likely to reduce the severity of these crashes. Second, by slowing trucks and buses, speed limiters may prevent some crashes involving trucks or buses hitting other vehicles. Third, if speed limiters cause trucks and buses to travel at speeds slower than the majority of traffic, it is possible that they may increase some crashes involving trucks or buses being struck by other vehicles, especially if the speed limiters are set well below posted speeds. This analysis focuses on the first effect, which we believe is the primary impact of speed limiters. We were unable to construct reliable estimates of the second two impacts. However, we believe that the second, positive effect on safety is likely to be greater than the third, negative effect on safety.

For the benefit analysis, 2004 - 2013 data from the National Automotive Sampling System General Estimates System (NASS GES) and Fatality Analysis Reporting System (FARS) were used to examine crashes involving combination trucks, single unit trucks, and buses traveling on roads with a posted speed limit of 55 mph or higher. Only cases in which both the speed of the heavy vehicle likely affected the severity of the crash (e.g., single vehicle crashes and crashes in which the heavy vehicle was the striking vehicle) and the travel speed of the heavy vehicle likely matched the speed profile were used in our predictive model. Considering this, there were a total of 11,056 vehicles with a GVWR greater than 11,793 kg (26,000 pounds) involved in fatal crashes in 10 years. This represents the target population for the analysis. Among the 11,056 vehicles involved in fatal crashes, 9,918 were combination trucks, 904 single unit trucks and the remaining 234 were buses.

To estimate the safety benefits associated with requiring speed limiting devices, we first used travel speed data from observational studies and the FARS & GES data to develop a model to predict how the fatal crash rate[4] (the ratio of the number of vehicles involved in fatal crashes to the total number of vehicles involved in police-reported crashes) would be affected by changing travel speed. We then used the probability of fatal crash (or odds ratio) to derive the percent reduction in the fatal crash rate that would result from reducing the travel speed of heavy vehicles traveling at speeds above a set speed (for example, 65 mph) to the set speed (i.e., how would the probability of a heavy vehicle crash being fatal change if the vehicles were limited to a set speed?). We note that in order to illustrate the methodologies used to estimate potential benefits and costs with a speed limiting device set at a particular speed, we illustrated our methodology using a maximum set speed of 65 mph in the PRIA and generally discussed only combination trucks, except where differences in calculations for single-unit trucks or buses were notable. However, we have also considered and made identical calculations for single-unit trucks and buses and for all three vehicle types with speed limiters set to 60 mph and set to 68 mph.

We then used the FARS data and the observed heavy vehicle travel speed data to estimate the number of fatal crashes at various travel speeds.

[4] The fatal crash rate represents the ratio of the number of vehicles involved in fatal crashes to the total number of vehicles involved in police-reported crashes. This value is calculated using the crash data from the FARS & GES databases.

Finally, we applied the percent reduction in the fatal crash rate for each travel speed above a set speed (derived from the model described above) to the estimated number of fatal crashes at each of those travel speeds to calculate the number of lives saved. Using this method, we estimate that, for example, a 65 mph-speed limiting device would save 63 - 214 lives, annually, including 62 - 204 lives saved in combination truck crashes, 1 - 5 lives saved in SUT crashes and less than one life to 5 lives saved in bus crashes.[5] We also expect that limiting heavy vehicles to 65 mph would prevent 1,283 - 4,452 minor injuries (AIS 1 & 2) and 68 - 238 serious injuries (AIS 3-5) annually. When the injuries prevented and lives saved are converted to Equivalent Lives Saved (ELS),[6] the result is 54 – 183 ELS discounted at 7% and 68 – 230 discounted at 3%.[7]

Using the same methodology as that used to calculate the safety benefits of limiting heavy vehicles to 65 mph, we estimate that limiting heavy vehicles to 68 mph would save a total of 27 - 96 lives, annually. Among the 27 - 96 lives saved, approximately 96% of all lives saved would be from combination truck crashes.[8]

The model used to estimate the safety benefits associated with reducing heavy vehicle travel speed to either 65 mph or 68 mph relies on the average heavy vehicle travel speed on roads with

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[5] The numbers are rounded to the nearest integer.
[6] As explained in the benefits section, ELS is derived from converting the nonfatal injuries prevented into fatality equivalents and adding that to the number of fatalities prevented.
[7] The estimated number of lives saved and injuries prevented are those (fatal and non-fatal) injuries that would be prevented when all applicable vehicles are in compliance with the rule, annually, or during the operational life of a model year vehicle. However, the ELS values show a discounting of the future stream of fatalities and injuries prevented. We discussed in detail the future stream of fatalities and injuries prevented in the cost-effectiveness chapter.
[8] With 68 mph speed limiting devices, we expect 27 - 92 lives would be saved in combination trucks crashes. For SUTs and buses, less than one life to 2 and less than 1 to 2 lives, respectively, would be saved with 68 mph speed limiting devices.

various posted speed limits (e.g., 55 mph, 60 mph, 65 mph, 70 mph, and 75 mph) and the risk of a crash resulting in a fatality versus an injury on those roads. The travel speed data shows that the average travel speeds for heavy vehicles on these roads are between 62 mph (55 mph roads) and 69 mph (70 mph roads)[9]) depending on the speed limit of the road. Therefore, 60 mph is outside of the range of travel speed means we have and, as explained in detail in the benefits section, we therefore do not have confidence in the ability of our model to predict the magnitude of the reduction in the fatal crash rate associated with reducing heavy vehicle travel speed to that speed. Although we believe that 60 mph speed limiters would result in additional safety benefits, for example, compared to limiting heavy vehicles to 65 mph, we are not able to quantify those additional benefits with any reasonable certainty.

Illustration of Annual Fatalities and Injuries Prevented by 65 mph Speed Limiting devices

	Lives saved		Injuries prevented	
Vehicle type	low est.	high est.	low est.	high est.
Combination trucks	62	204	1,351	4,440
Single unit trucks	1	5	19	102
Buses	0	5	0	112
Total lives saved	63	214	1,370	4,654

* The numbers are rounded to the nearest integer.

Illustration of Annual Equivalent Lives Saved (ELS) 65 mph Speed Limiting devices

	ELS*			
	low est.		high est.	
Vehicle type	3%	7%	3%	7%
Combination trucks	67	53	220	175
Single unit trucks	1	1	5	4
Buses	0	0	5	4
Total lives saved	68	54	230	183

* The numbers are rounded to the nearest integer.

[9] The travel speed data found slightly higher average travel speeds on 70-mph roads than on 75-mph roads.

In addition to reducing fatalities and injuries, for example, 65 mph speed limiting devices would result in $54 - $181 million in property damage savings discounted at 7% ($67M - $229M at 3%).

Illustration of Property Damage Prevented with 65 mph Speed Limiting devices ($M, in 2013 dollars)

	Discount 3%		Discount 7%	
	Low Estimate	High Estimate	Low Estimate	High Estimate
Property Damage Savings	$67	$229	$54	$181

The agencies request comment on the method used to estimate safety benefits and how the agencies can improve the analysis. The agencies may consider alternative methods to estimate safety benefits if the agencies move forward with a final rule.

The proposed speed limiting device rule would not only result in safety benefits but also reduce fuel consumption by increasing fuel efficiency. According to the 2013 vehicle miles traveled (VMT) data, combination trucks, single unit trucks and buses had a total of 116 billion VMT (115,906 million miles) on rural and urban interstates. For illustration, when the travel speed of heavy vehicles is limited to 65 mph, 344 million gallons of fuel would be saved annually, and Greenhouse Gas (GHG) emissions would be reduced by 3.5 million metric tons, annually.[10, 11, 12]

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[10] We note that heavy vehicles manufacturers may use a speed limiting device along with other technologies to meet the heavy vehicle GHG and fuel efficiency standards. However, to estimate the benefits of those standards, NHTSA and EPA estimated the fuel savings that would result from speed limiting devices using 65 mph as a baseline and calculating the fuel savings for speed limiting devices set below 65 mph. The fuel savings from reducing heavy vehicle speeds to 65 mph from higher speeds was not accounted for in that rulemaking.
Limiting heavy vehicles to 68 mph would result in $283 million in fuel savings at 7% discount.

The agencies request comments on these estimates and how the agencies can improve the analysis.

Summary of annual fuel saving, illustration of 65 mph speed limiting devices
(in millions of gallons & 2013 dollars)

Vehicle Type	Fuel and $ savings			
	Fuel (mil. of gal.)	no-discount	3%	7%
Combination truck	304	$984	$796	$632
Single unit truck	32	$98	$80	$63
Bus	8	$26	$21	$17
Total	344	$1,108	$897	$712

Summary of annual benefits, illustration of 65 mph speed limiting devices
(in millions of 2013 dollars)*

Benefits	3% Discount		7 % Discount	
	Low Estimate	High Estimate	Low Estimate	High Estimate
Monetized Benefits of Reducing Fatalities, Injuries and property damages savings	$879	$2,888	$706	$2,322
Fuel and GHG Savings	$947	$947	$752	$752
Total Annual Benefits	$1,826	$3,835	$1,458	$3,074

* The numbers were rounded to the nearest integer.

Costs:

We expect the equipment costs associated with a speed limiting device would be insignificant for heavy vehicle manufacturers because new heavy vehicles with a GVWR greater than 11,793 kg

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[11]We use the proposed MD/HD CAFE Phase 2 standard as the primary baseline for measuring fuel savings.

[12] To determine the benefits of reduced GHG emissions, the agencies estimated the benefits associated with four different values of a one metric ton carbon dioxide reduction (model average at 2.5% discount rate, 3%, and 5%; 95th percentile at 3%). These values were developed by an interagency working group to allow agencies to incorporate the social benefits of reducing carbon dioxide emissions into their cost-benefit analyses. The agencies have used the 3% discount rate value, which the interagency group deemed as the central value, in the primary cost-benefit analysis. For internal consistency, the annual benefits are discounted back to net present value using the same discount rate as the social cost of carbon estimate (3%) rather than 3% and 7%. Accordingly, the 3% value is used for both the 3% and 7% discount rate benefits estimates.

(26,000 lbs.) already use electronic engine control units (ECUs) with speed limiting capability. Regarding compliance test costs, vehicle manufacturers can use any appropriate method to self-certify the performance requirements, including engineering analysis/calculation, computer simulation and track testing. We believe that manufactures would not need to conduct any additional tests beyond what they and their suppliers are currently conducting to verify the performance specifications. We request comment on these tentative conclusions.

However, since the proposed rule would limit travel speeds to a particular speed, commercial vehicle drivers who are currently driving at or near the maximum daily allowable driving hours (11 hours within a 14-hour period measured from the beginning of the work day for truck drivers, and 10 hours within a work day of up to 15 hours of on-duty time for bus drivers),[13] in areas with posted speed limits greater than the set speed, would not be able to reach their destination in the same amount of time. For example, we estimate that the overall delay in delivery or travel time would increase by 3% when the vehicles are limited to 65 mph.

Societal Costs:

According to guidance issued by DOT, the recommended value of travel time (VOTT) of personal intercity travel time is 70% of total earnings. Accordingly, the personal intercity VOTT is used as another measure of the opportunity cost ($17.50 in 2013 dollars).[14] In addition to the

[13] See 49 CFR Part 395.
[14] Revised Department Guidance on Valuation of Travel Time in Economic Analysis, July 9, 2014. According to the guidance, the value of travel time (VOTT) is $17.50 in 2013 dollars.

costs associated with lost opportunity, we included freight inventory costs due to the delay in delivery time. According to FHWA, the hourly freight inventory costs are estimated to be $0.31 and $0.18 for combination trucks and single-unit trucks, respectively.[15]

Illustration of opportunity costs associated,
with 65 mph speed limiter, in millions, in 2013 dollars

Vehicle	Hours, in M's	Societal cost/hr	Not discounted	3%	7%
Combination truck	40	17.50	$699	$566	$449
SUT	5	17.50	$82	$66	$52
Bus	1	17.50	$20	$16	$13
Total	46	17.50	$801	$648	$514

Illustration of inventory costs associated,
with 65 mph speed limiter, in millions, in 2013 dollars

Vehicle	Not discounted	3%	7%
Combination truck	$13.2	$10.7	$8.5
SUT	$1.1	$0.9	$0.7
Bus	$0	$0	$0
Total	$14.3	$11.6	$9.2

Illustration of societal costs associated,
with 65 mph speed limiter, in millions, in 2013 dollars*

Vehicle	Not discounted	3%	7%
Combination truck	$712	$577	$457
SUT	$83	$67	$53
Bus	$20	$16	$13
Total	$815	$659	$524

* The numbers were rounded to the nearest integer.

We note that since truck drivers are currently paid by miles driven, some drivers would drive longer hours to cover the same distance and avoid a reduction in pay. If drivers have to drive longer hours to cover the same distance, there would be lost opportunity costs for the additional

[15] "Work Zone Mobility and Safety Program," Work Zone Road User Costs - -Concepts and Applications, Section 2.2.2.5, Example 2.6. http://ops.fhwa.dot.gov/wz/resources/publications/fhwahop12005/sec2.htm

time. The value of opportunity cost can change dramatically depending on how much of it the truck drivers have available and how they use it. The drivers would likely value the delay, such as getting home half hour later, much more highly if the drivers are very busy or other economic opportunities are lost due to the delay.

The overall societal costs due to increase in delivery time with 68 mph speed limiting device was estimated to be $228 million and$185 million discounted at 3% and 7%, respectively (in 2013 dollars). The overall societal costs due to increase in delivery time with 60 mph speed limiting device were estimated to be $1,704 and $1,353 million discounted at 3% and 7% (in 2013 dollars).

Illustration Summary of societal costs associated with the delay in delivery time, With 65 mph speed limiter, in millions, 2013 dollars*

Cost	CT		SUT		Bus		Total	
	3%	7%	3%	7%	3%	7%	3%	7%
Opportunity lost cost	$566	$449	$66	$52	$16	$13	$648	$514
Inventory	$10	$8	$0.9	$0.7	$0	$0	$11.6	$9.2
Total	$577	$457	$67	$53	$16	$13	$659	$524

* Numbers were rounded to the nearest integer.

Net Impact:

<u>Societal net impact:</u>

We expect the equipment costs associated with the proposed speed limiting device with the time stamping would be insignificant. In addition, the fuel savings from the proposal would be on average greater than the combined total cost of the opportunity lost and the lost value of inventory. Therefore, with the safety benefits, the proposed rule would be cost beneficial. For example, the net societal benefit for combination trucks was estimated to be $1.0 billion to $2.6 billion with 65 mph speed limiters, annually, based on current average wages.

Illustration of Net Societal Cost, annual,
with 65 mph speed limiters,
Based on average wages, in millions, in 2013 dollars, at 7%

Vehicle	Approach	Vehicle-based		Person-based	
CT	Odds ratio	1.047	1.154	1.033	1.150
	Net benefit	$1,250	$2,616	$1,000	$2,587
SUT	Odds ratio	1.014	1.079	1.035	1.097
	Net benefit	$32	$67	$45	$75
Bus	Odds ratio	1.000	1.081	1.024	1.165
	Net benefit	$7	$40	$20	$65

* A negative net cost indicates an estimated societal savings

Fleet net impacts:

In order to compensate the delay in travel or delivery time, we assume trucking and bus companies would hire additional drivers and use team driving strategies in some cases. For the additional drivers, we assumed that the hourly cost to the companies equals to the current average wage plus fringe benefits. Fringe benefits include paid leave, bonuses and overtime pay, health and other types of insurance, retirement plans, and legally required benefits (Social Security, Medicare, unemployment insurance, and workers compensation insurance).

In the Electronic Logging Device (ELD) Supplementary Notice of Rulemaking (SNPRM) Regulatory Impact Analysis (RIA), FMCSA assumes that drivers value their leisure time at the same amount that they accept in exchange for it, that is their base wage plus fringe benefits. FMCSA estimates that fringe benefits are equal to 55 percent of wages. Based on the SNPRM, we assume that the cost of fleet to hire drivers could be equal to the current driver wage plus 55 percent of the wage.

Regarding how trucking companies respond to the proposed rule, with a relatively large amount of resources such as contingent drivers and trucks, large trucking companies could react in several ways to deal with the proposed speed limiter rule. We used two potential scenarios to estimate the costs associated with a speed limiter. First, drivers could drive longer hours (within the 11 hours restriction) but keep the same miles traveled. Some large companies would need to hire additional drivers because not all current drivers would be able to drive the additional hours necessary to deliver as many loads. Second, we could assume that drivers will be paid the same amount/income for the fewer miles driven with the same amount of driving hours. As a result, their current hourly wage would remain the same. To cover the delay in delivery time, large trucking companies would hire new drivers. Under either scenario, we do not expect that small operators and owner-operators will be able to compensate for the effects of this proposed rule by hiring additional drivers, and will compensate as much as they can by driving additional hours. Ultimately, we believe that some of the deliveries currently made by small operators and owner-operators will need to be delivered by operators who have the capability of hiring additional drivers.

The agencies request comment on the method used to estimate the costs to drivers and heavy vehicle operators and how the agencies can improve the analysis. The agencies may consider alternative methods to estimate costs if the agencies moves forward with a final rule.

Because the trucking/busing industry would bear the cost to hire additional drivers but also directly benefit from the fuel savings, it is important to consider the net cost to that industry. Our analysis indicates that under all assumptions, the trucking/busing industry would gain a net benefit from this rulemaking. While the industry as a whole would bear the cost to hire additional drivers, it is also important to consider that only those fleets driving above a required set speed would bear cost and realize benefits.

In addition, the savings from a speed limiter are potentially small for a single truck and very sensitive to fuel costs. For example, in 2013 a combination truck on average traveled 68,155 miles and the average hourly rate for a general freight operator was $20.8. If the speed limiter setting for a single truck was decreased from 70 mph to 65 mph, moving goods would take 32.8 hours longer each year costing $659 for additional labor for the year. This cost would be offset by savings 277 gallons of fuel. In order to understand if such a company policy would be financially beneficial to the operation, the price of fuel (including taxes paid by the fleet) must be considered. In this case, if the price of fuel is less than $2.38 per gallon, limiting the speed setting from 70 mph to 65 mph would not be financially beneficial, but if the price of fuel was greater than $2.38 it would be. Considering that the price of fuel fluctuates, the discrepancy between various fleets speed settings, or no setting, could be caused by differences in the projected price of fuel for the year. Further, the operation cost of a single truck is around $100,000 annually and, for example, the net savings resulting from limiting a truck from 70 mph down to 60 mph at $4.00 per gallon would be $775, or 0.7% of the total operating cost. Given that, relative to the total cost of operation, the cost savings that can achieved by the use of a speed limiter, and that the cost savings fluctuates based on the price of fuel, voluntarily utilizing a speed limiter for a small fleet may not be an advisable choice for fleet managers based on cost alone.

Illustration of fleet fuel savings (with after-tax fuel cost), with 65 mph speed limiter, in millions

Gallons	Total	3%	7%
304	$1,115	$902	$716
32	$111	$90	$72
8	$30	$24	$19
344	$1,256	$1,017	$807

Illustration of Annual Cost to Fleet, 65 mph speed limiters,
Based on average wages, Scenario 2, with after-tax fuel unit cost, in millions, in 2013 dollars

Net cost to fleet	CT		SUT		Bus	
	3%	7%	3%	7%	3%	7%
Cost to hire drives	$710	$564	$83	$66	$0.5	$0.4
Inventory cost	$11	$8	$0.9	$0.7	$0	$0
Fuel saving	$902	$716	$90	$72	$24	$19
Net Cost impact to fleet*	-$181	-$144	-$6	-$5	-$23.5	-$18.4

* A negative net cost indicates an estimated fleet savings

Illustration of Net Annual Cost to Fleet, 65 mph speed limiters,
Based on average wages, Scenario 1, with after-tax fuel unit cost, in millions, in 2013 dollars

Net cost to fleet	CT		SUT		Bus	
	3%	7%	3%	7%	3%	7%
Cost to hire drives	$18	$14	$2.1	$1.7	$0.5	$0.4
Inventory cost	$11	$8	$0.9	$0.7	$0	$0
Fuel saving	$902	$716	$90	$72	$24	$19
Net Cost impact to fleet*	-$873	-$694	-$87	-$70	-$23.5	-$18.5

Impacts on Small Trucking and Bus Businesses:

If heavy vehicles are required to be speed limited to specific speed, it could put owner-operators and some small fleet owners at a significant disadvantage due to several factors working against them. There are transport jobs that small trucking companies could bid on and arrive sooner compared to a firm that already voluntarily uses a speed limiting device, for example, if they can drive at 75 mph, which is the speed limit on some roads. Thus, it is likely that there are some jobs where there is an apparent competitive advantage to being able to drive faster than the set speed of a particular speed limiter. For example, some small trucking businesses whose drivers currently travel at faster speeds might not be able to expand quickly enough to make the extra trips necessary to compensate for the increased travel times resulting from mandatory speed limiters. Instead of these small independent trucking companies buying new trucks and/or hiring additional drivers, we expect that large trucking companies would absorb the additional cargo with their reserve capacity of trucks but would need to hire additional drivers. We are soliciting comments from the public regarding the assumption that large trucking companies would absorb the additional cargo. As a result, the overall travel distance by trucks owned by small independent trucking companies would decrease as the overall travel distance by trucks owned by large trucking companies would increase. Although we do not expect additional cost to the trucking industry as a whole in the near future from this rulemaking, small trucking companies, especially independent owner-operators, would be less profitable with speed limiting devices. We have very limited data to predict how the affected owner-operators would compensate for the delay in delivery time. We expect that some of the affected owner-operators would work for trucking companies as independent contractors. If all of the affected owner-operators worked as independent contractors, for example, with 65 mph speed limiters, they would lose $54 million in labor income due to lower wage earned as contractors.[16] We seek comments and data from potentially affected parties to help us refine these estimates.[17]

Illustration of potential small business income lost
with 65 mph speed limiter, in M's, $2013 dollars

Vehicle Type	Income lost
Combination truck	$44
SUT	$6
Bus	$5
Total	$54

[16] These small business costs are not considered societal costs of the rule. The costs were not reflected in the cost estimate. Rather, these costs to small business reflect a potential for the transfer of business from small businesses to large businesses.

[17] For buses, since almost all bus companies would be small companies, for the analysis, due to limited data, we assumed that all bus companies are small companies. Motor Carrier Management Information System (MCMIS) http://mcmiscatalog.fmcsa.dot.gov/

Regarding bus companies, we believe that the companies most likely to be affected would be those that operate motorcoaches, which tend to be larger buses that are used for traveling longer distances. We have very limited data to predict how affected small motorcoach companies would compensate for the delay in delivery time. Some companies may be able to hire additional drivers.

Although this rulemaking is expected to result in large fuel savings to the trucking industry as a whole, the agencies are unable at this time to estimate the distribution of those savings or how they might offset the costs to small trucking and motorcoach businesses. The agencies request comment on ways to estimate the fuel savings for these operators.

As part of the Environmental Assessment, the agencies ran the MOVES2014a model using the national scale domain, which is described in the technical support documents on EPA's website. To model various set speeds, the agencies modified the "Average Speed Distribution" input parameter for each set speed based on the speed distributions used throughout this document. The model's outputs included emissions and fuel consumption. The fuel consumption results of this analysis provide a rough gauge by which the fuel consumption results presented in this document can be compared. A direct comparison is not possible because the MOVES2014a model provides future VMT based upon assumed future VMT growth estimates and fuel while the fuel benefits reported in this section are not adjusted for future projected VMT. MOVES2014a-generated VMT are predictions of the future while the VMT used in our analysis presented in this document is based on 2013 conditions. The table below summarizes the results of the agencies MOVES2014a analysis for various maximum set speeds.

MOVES2014a and Phase I CAFE Baseline Results of Diesel Fuel Saved Annually

	60 mph	65 mph	68 mph
MOVES2014a Gallons of Fuel (millions)	1,005	500	131
Phase I CAFE Baseline Gallons of Fuel (millions)	863	423	188

It should be noted that the Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles; Final Rule, 76 FR 57106 (September 15, 2011), Phase I CAFE are incorporated in the default database of the MOVES2014a model. The Phase 2 medium- and heavy-duty fuel efficiency rule has not been incorporated into MOVES2014a.

Alternatives:

In addition to the set speed alternatives, we examined feasibility of potential regulatory alternatives based on technologies that could limit the speed of a heavy vehicle to the posted speed limit of the road. These technologies might include a GPS, vision system, vehicle to infrastructure communication, or other types of autonomous vehicle technology. Although we are not proposing these alternatives in the NPRM, the agencies request comment addressing the feasibility of such technologies as a potential regulatory alternative option to the speed limiting device requirement with a set maximum speed. Use of these technologies could potentially have the effect of reducing fatalities while limiting the economic effects of this rule. Our preliminary conclusion is that requiring these technologies to limit vehicle speed would not be feasible and/or cost-effective at this time, but the agencies are seeking comments from the public on this preliminary conclusion. The agencies would not publish a final rule requiring speed limiters using these technologies without first publishing another proposed rule addressing them.

Effect of Speed Limiting devices on Preventing Crashes:

The impact of reductions in travel speed will, in most cases, result in a reduction in the impact velocity, and hence the severity of the crash. However, in some cases, reduced travel speed will actually prevent the crash from occurring. This would result, for example, if the braking vehicle were able to stop just short of impacting another vehicle instead of sliding several more feet into the area it occupied when brakes were applied during the crash. In theory, current crashes occur under a variety of stopping distances but if these distances were shortened due to the slower travel speed of a truck, then a portion of these crashes would be prevented. Accordingly, limiting the speed of heavy vehicles to a particular speed limit may decrease the probability of being involved in a crash.

On the other hand, limiting heavy vehicle speed could result in differential speeds between those vehicles and light and medium vehicles, particularly on roads where the posted speed limit is higher than the set speed. For example, the average speed difference between passenger vehicles and heavy vehicles could increase the probability of crashes when a car is closely following a slower truck and the truck suddenly brakes in response to a hazard, resulting in the passenger vehicle hitting the rear of the heavy vehicle.

As part of the cost-benefit analysis, the agencies examined several studies on differential speed limits. These studies have generally found that the probability of being involved in a crash per vehicle-mile as a function of on-road vehicle speed follows a U-shape curve with vehicles traveling near the median speed having the lowest probability of being in a crash. In particular, the speed curve developed by West and Dunn[18] shows that the likelihood of being involved in crashes would vary only slightly within 15 mph of the median. Specifically, traveling 5 to 15 mph lower than the median speed is associated with a relative crash involvement rate of 0.71 involvements per million vehicle miles versus 0.8 involvements per million vehicle miles at the median speed. This indicates that even though limiting heavy vehicles to, for example, 65 mph may increase the speed differential between these vehicles and the median travel speed on some roads, 65 mph speed limiting devices may actually reduce the risk of heavy vehicles being involved in a crash on roads where mean travel speeds are less than 80 mph (i.e., 15 mph greater than 65 mph). Although the speed curve developed by West and Dunn is only one of many studies examining the probability of being involved in a crash, we believe that it provides a reasonable basis for the conclusion that limiting the speed of heavy vehicles to 65 mph or higher would not increase the probability of being involved in a crash, given that there are very few highway segments in the U.S. with a posted speed limit greater than 80 mph. (For additional discussion, see "Effects of Differential Speed Limits on Safety" in the benefit chapter.) However, we become less confident in this conclusion for set speeds lower than 65 mph.

After considering this research and the difficulty in estimating the effect of speed limiting devices on crash risk, the agencies have chosen not to include an estimate of crashes avoided and to only estimate the safety benefits of reducing crash severity. The agencies believe that speed limiting devices will likely reduce both the severity and risk of crashes. However, the agencies

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[18] Research Triangle Institute, "Speed and Accident, Volume II," Report No. FH-11-6965, National Highway Safety Bureau, June 1970

have greater confidence that the estimated crashworthiness benefits described will be fully realized because, by focusing on crash severity, the agencies are able to isolate more effectively the effects of speed reduction on safety. The agencies request comments on potential methods to estimate the crash avoidance benefits of speed limiting devices. The agencies may consider including such an analysis if the agencies move forward with a final rule.

Market failure:

Executive Order 12866 states that agencies contemplating regulation "…should promulgate only such regulations are required by law, are necessary to interpret the law, or are made necessary by compelling need, such as material failures of private markets to protect or improve the health and safety of the public, the environment, or the wellbeing of the American people…" It further states that agencies shall "…identify the problem that it intends to address (including, where applicable, the failures of private markets or public institutions that warrant new agency action) as well as assess the significance of the problem." The market failure that justifies examining regulation of heavy truck travel speeds results from the nature of the delivery industry. The commercial delivery market functions in a manner that incentivizes high speed delivery of goods. Independent truck drivers' incomes are tied to the amount of goods they deliver, and this is a direct function of the time it takes to complete a delivery. This directly incentivizes truckers to drive faster, so as to maximize the amount of goods they can deliver. There may be an even greater incentive because many large operators use speed limiters while many small operators and owner-operators do not. The small operators and owner-operators have an incentive to drive faster to obtain a competitive advantage. While high speed may provide a benefit to drivers,[19] it imposes added risks and environmental pollution on the rest of society. The commercial market thus fits the classic definition of a "negative externality", in which benefits are enjoyed by one party, but the costs associated with that benefit are imposed on another. In this case, high travel speed produces traffic crashes that result in death, injury, and property damage. In addition, these crashes cause congestion related expenses such as lost time for third parties, excess gasoline consumption, greenhouse gas production, and criteria pollutant production. Excess fuel consumption and the associated greenhouse gases and criteria pollutants also result from everyday operation of vehicles travelling at high speeds. The added fuel consumption is a direct expense to the independent truck driver, but it may be passed on in the form of higher delivery prices.

[19] Driving at higher speeds may or may not provide a benefit to the recipients. For example, a business receiving a delivery may need to have employees available to unload a truck. If those employees are not available, the truck must wait at the delivery point to be unloaded. A truck driver who must deliver a load in the morning may arrive at the unloading point the evening before, in which case arriving a few minutes (or even hours) later will not affect the recipient of the delivery.

I. INTRODUCTION

The purpose of this report is to present the potential costs and benefits of speed limiting devices on heavy vehicles in the U.S. The information offered here pertains to the impact of speed limiting devices on costs (vehicle costs and time delay), benefits (fatality, injury and property damage prevention), and fuel savings. In addition, the report analyzes how speed limiting devices affect small business and the trucking industry as a whole.

Background

Speed limiting devices, or speed governors, have been in use since the mid 1990's by many trucking fleets to control the speed of commercial trucks. They are generally part of the truck's Electronic Control Unit (ECU) and limit the top speed the vehicle can travel. Research shows that they are currently being used by 77% of trucks on the road in the United States.[20] The main reasons cited by trucking fleets for using speed limiting devices are reduced fuel costs, less equipment wear and tear, and increased safety. However, some smaller fleets and most owner operators are opposed to the idea of speed limiting devices, claiming that speed limiting devices are just an attempt by powerful associations representing large trucking firms to reduce the competitive advantage of smaller fleets and owner operators and to eliminate competition. They believe that speed limiting devices will significantly affect their ability to continue with current

[20] Ray Barton Associates, Trade and Competitiveness Assessment of Mandated Speed-Limiting devices for Heavy Trucks Operating in Canada, prepared for Transport Canada, https://www.tc.gc.ca/eng/motorvehiclesafety/tp-tp14813-menu-365 htm.

delivery schedules, thus losing money. Those opposed to the limiting devices also claim that limiting the top speed of heavy vehicles will create a dangerous speed differential between them and other light vehicles on the road. They claim that this could cause an excess of vehicle congestion and increase the likelihood of crashes involving heavy vehicles and light vehicles.

The safety argument in favor of speed limiting devices is that slowing down heavy vehicles will reduce crash occurrence and severity. Heavy vehicles take longer to slow down and are more difficult to maneuver around obstacles, which makes them more dangerous to operate at high speeds. Additionally, as is true of all vehicles, higher speeds mean that the driver has less time to react.

Traveling at speeds faster than the speed limit or faster than what is safe for conditions increases the risk of a crash, but it is possible that creating a speed differential between vehicles on a highway also increases the risk of a crash. Proponents of this theory claim that if there is a difference in speed between vehicles traveling on a highway, the frequency of vehicle interactions increases, thus, there is a greater chance of a collision. They also claim that reducing their speed increases their chances of getting rear ended, makes passing more difficult, and makes merging into traffic more dangerous.

The European Union has limited the speed of large trucks and buses under its jurisdiction to 62 mph since 1994. In Australia, large trucks have been limited to 62 mph since 1990 with a 56-mph limit for road trains (a road train consists of a combination truck pulling multiple trailers). The European Union and Australia cited economic and safety benefits as the reasons for adopting large truck speed limiting device legislation and regulation. The Australian Design Rule (ADR) 65/00--Maximum Road Speed Limiting for Heavy Goods Vehicles and Heavy

Omnibuses specifies the devices or systems used to limit the maximum road speed of heavy goods vehicles.

After the United Kingdom mandated speed limiting devices in 1992, crashes involving heavy trucks fell by 26% the following year. Furthermore, crashes involving heavy trucks in Australia have also dropped over the 10 years since implementing speed limiting devices. However, in Australia and all the European Union member states, none have done any research to show that speed limiting devices are the direct cause of reduced heavy vehicle crashes. Other factors such as roadway improvement and revised safety standards could also be responsible for a reduction in heavy vehicles crashes. Therefore it is difficult to determine exactly what effect speed limiting devices had on vehicle safety in the United Kingdom and Australia.

More recently, Japan and the Canadian provinces of Ontario and Quebec have also mandated speed limiting devices. Japan limited large trucks to 56 mph in 2003. Quebec and Ontario limited the speed of large trucks to 65 mph effective January 1, 2009, although they did not begin assessing fines until July 1, 2009. In addition to economic and safety benefits, the two provinces cited environmental benefits.

II. BENEFITS

NHTSA is proposing that each multipurpose passenger vehicle, truck, and bus with a gross vehicle weight rating (GVWR) of more than 11,793.4 kilograms (26,000 pounds) be equipped with a speed limiting device.

FMCSA is proposing that each commercial motor vehicle with a GVWR of more than 11,793.4 kilograms (26,000 pounds) be equipped with a speed limiting device meeting the requirements of the proposed FMVSS applicable to the vehicle at the time of manufacture, including the requirement that the system be set to a particular speed. Motor carriers operating such vehicles in interstate commerce would be required to maintain the speed limiting devices for the service life of the vehicle.

Based on these two proposed requirements, this analysis examines the safety benefits from limiting heavy vehicles (combination trucks, single-unit trucks and buses) to a particular speed.[21]

Throughout this analysis, to simplify matters, we will show how we calculated benefits for speed limiters set to 65 mph, and primarily for combination trucks. However, we have also considered and made identical calculations for single-unit trucks and buses and for all three vehicle types with speed limiters set to 60 mph and 68 mph. The NPRM does not propose a specific set speed

[21] Although we understand that some carriers currently use speed limiters set at various speeds, we do not have data on the crash risk between carriers who currently use speed limiters and those that do not. In the 2008 Commercial Truck and Bus Safety Synthesis of Safety Practices Report results from 103 fleet safety managers showed that reducing crashes was the second most common response.

requirement, but the agency would specify a maximum set speed in a final rule implementing this proposal.[22]

A. Overview of Methods.

Speed limiters may affect both the likelihood and the severity of crashes. Our analysis focuses on speed limiters' effect on the severity of crashes. Basic physics suggests that crashes at lower speeds will be less severe than crashes at higher speeds, as kinetic energy equals (1/2(mass)(velocity^2)), meaning that even small increases in speed have large effects on kinetic energy. Thus, the agency expects that, by limiting the speed at which heavy vehicles can travel, the severity of the crashes that would have occurred at higher speeds will be reduced.

The safety benefits analysis estimates the effect of reduction in speed on the severity of injuries in crashes, without assuming that the total number of crashes would be decreased. In order to estimate the potential safety benefits, we developed two different logistic models based on 2004 – 2013 Fatal Accident Report System (FARS) and General Estimate System (GES) data basses. The overview of the target population, logistic model and safety benefit are discussed below.

<u>Overview of target population:</u>

For the benefit estimate, we extracted fatal crash records from FARS and non-fatal crash records from GES, including variables describing vehicles involved in crash, crash circumstances (potential causal factors), and occupant characteristics. The crash records include those involving combination trucks, single-unit trucks, and buses. (We note that GES is a sample of

[22] Results for 60 mph and 68 mph speed limiters are reported in Appendix I.

non-fatal crashes, while FARS includes all fatal crashes.) We then merged FARS and GES crash records to calculate (a) the probability that a crash will result in one or more fatalities, and (b) the probability that each occupant of a vehicle involved in a crash will suffer a fatal injury. In addition, we adjusted the baseline crash data to account for reductions in fatal crashes due to changes in NHTSA safety standards.

Overview of logistic regression model:

(1) First, we calculated a distribution of travel speeds using the mean and standard deviation of speeds observed on roads with different posted speed limits. (2) Second, we assigned speed data to individual crash records using two methods: (a) assume all vehicles travel at the mean observed speed within same speed limit; and (b) assume a normal distribution of speeds within the same speed limit based on the observed mean speed and standard deviation. (3) Third, we estimated logistic regression models for the (conditional) probability that a crash will result in one or more fatalities ("vehicle-based" models), and for the probability that each occupant of the vehicles involved in a crash will suffer a fatal injury ("person-based" models). The vehicle-based and person-based models include (a) multivariate models using mean speed; and (b) multivariate models using speeds assigned from distribution.[23] For multivariate vehicle-based models, explanatory variables include speed, number of lanes and weather conditions; for multivariate person-based models, explanatory variables include speed, number of lanes, weather

[23] In Appendix A, we have also included a single-variable model with speed as the only explanatory variable using speeds assigned from a distribution. The results of our analysis using this method fall within the range of benefits determined using the multivariate models.

conditions, occupant age and sex, seating position within vehicle, and seat belt use. (4) Fourth, we distributed fatal crashes occurring from 2004-2013 according to the mean and standard deviations observed in the previously referenced research.

Overview of safety benefit estimate:

For the safety benefit estimate, we used the regression models to calculate the expected reduction in number of fatal crashes and the total number of fatalities resulting from limiting heavy vehicle travel speeds. There are three main steps for the estimate. (1) The first step was to estimate the travel speeds and risk of fatality on roads in order to develop a model to predict the risk of fatality as a function of travel speed. (2) The agencies then broke down the target population of fatal crashes by posted speed limit. (3) Finally, we used the models to estimate the lives saved if vehicles traveling above a particular speed are limited to the speed with speed limiters.[24] For the vehicle-based models, reduction in fatalities is estimated from the reduction in number of crashes multiplied by average fatalities per fatal crash; for the person-based models, the reduction in fatalities is estimated directly from estimated coefficients on speed. We then estimated reductions in non-fatal injuries occurring in fatal crashes using ratios of AIS 1-5 injuries to fatalities from a previous NHTSA rulemaking.

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[24] The maximum travel speed of these vehicles would be limited by speed limiters set at a particular speed, and we expect that most heavy vehicle drivers would likely travel at or near the maximum allowable speed. However, some of these trucks may end up traveling below the set speed as a result of the speed limiting devices. Because, in general, the risk of fatal crash would be lower as the travel speed decreases, we may be underestimating the benefit estimates. On the other hand, a vehicle equipped with a particular speed limiting device could move at a speed slightly higher than the set speed as it goes down the hill, meaning that for some segments of road, this methodology may overestimate benefits.

The results of this analysis varied based upon a number of factors, including whether the agency used the mean speed or distribution-based speed and the type of vehicle at issue. However, the results all showed that, consistent with our expectations based on basic physics, reducing the speed of heavy vehicles leads to less severe crashes and, thus, lives saved and injuries prevented. The target population, model and safety estimate are further discussed in detail below.

However, the agency's estimates have several limitations. Most importantly, the agency does not have real world data on travel speeds at the time of a crash, which necessitates simulations of crash travel speeds. The agency attempts this simulation using two separate approaches, both of which have significant limitations. In both cases, the agency relies on travel speed data from a small non-representative sample of roads. The first approach assigns each crash the mean speed by the speed limit of the road, taking no account of the variance in speeds by speed limit. In reality, fatal crashes occur at varying speeds, even on roads with identical posted speed limits. We cannot determine whether this method underestimates or overestimates benefits. The second approach assumes a normal distribution of crash speeds for each speed limit, though the agency does not have evidence that fatal crash travel speeds are normally distributed. However, crash physics suggest that crashes at higher speeds are more likely to be fatal than crashes at lower speeds. Without actual travel speed data from fatal crashes, however, this assumption cannot be confirmed or quantified. These factors limit the precision and explanatory power of the models the agency uses to estimate the effect of travel speed on fatality risk. The agency solicits comments on how it may overcome these data limitations in its analysis of the final rule.

<u>Target population:</u>

The target population was established using 10 years of crash data from NHTSA's Fatality Analysis Reporting System (FARS) for combination trucks, single unit trucks (SUT) and buses. This database contains information on crashes that involved heavy vehicles resulting in at least one fatality. The crash data indicate various crash, vehicle and occupant / non-occupant information, including the speed limit of the highway on which the crash occurred. This is later used (in combination with observational travel speed data from several States) to estimate the travel speed. In establishing the target population, the agencies included only those crashes most likely to be affected by heavy vehicle speed limiting devices. In particular, only those crashes whose severity was likely influenced by the speed of the heavy vehicle (e.g., crashes in which the heavy vehicle was the striking vehicle with the principal impact of the heavy vehicle at the front or front side) and only crashes in which the heavy vehicle was likely traveling at a high travel speed (e.g., rural and urban interstates, freeways and expressways, and principal arterials) were included.[25] As described later, our benefits model predicts an estimated reduction in the number of fatal crashes and fatalities based on a particular speed limiter (where the reduction in fatal crashes can then be converted to lives saved). As such, we are presenting the target population in terms of both the number of fatal crashes and the number of fatalities resulting from those crashes.

[25] For the target population, we have: Collision includes only Front to Rear and Front to Side (Same Direction), Speed Limit includes 55, 60, 65, 70, 75, 80; Traffic Way Flow excludes only Entrance/Exit Ramp; GVWR includes 26,000 lb. and Up; Principal Impact Point are 1, 2, 10, 11, 12, O-clock; Roadway Functional Class includes Interstate (Rural and Urban), Freeways or Expressways, Other Principal Arterial (Rural and Urban).

From 2004 to 2013, there were 9,918 fatal crashes involving combination trucks with a GVWR over 26,000 pounds on roads with a posted speed limit of 55 mph or higher of the types described above, resulting in 10,412 occupant fatalities.[26] For the same period, there were 904 fatal crashes involving single unit trucks with a GVWR over 26,000 pounds resulting in 958 occupant fatalities and 234 fatal crashes involving buses with a GVWR over 26,000 pounds resulting in 303 occupant fatalities involved in fatal crashes on roads with posted speed limits of 55 mph or greater.

[26] Our data on estimated speed at the time of crashes is limited. For fatal crashes, the majority of crash reports have "unknown" coded as the actual travel speed. We are basing our benefits estimate on the estimated travel speed of all trucks. This data is broken down by posted speed so that we can take the observations of truck speeds on certain roads in sample states and extrapolate nationally.

Table 1
Fatal crashes involving vehicles with a GVWR greater than 4,536 kg (26,000 lbs.)
FARS 2004-2013, 10 years and on inter-state highways /principal /expressways

	>26,000 lbs (within 55-75 MPH limits)
Striking CT	9,918
Striking SU	904
Striking BUS	234
All	11,056

Table 2
Striking Combination Trucks (>26,000 lbs) involved in Fatal Crashes by Highway Types (FARS 2004-2013)

Speed limit	Rural-Interstate	Rural Principal Arterial Other	Urban Interstate	Urban Freeway / Expressway	Urban Principal Arterial Other	Total
55	200	1,902	515	148	368	3,133
60	105	313	249	49	52	768
65	1,060	1,024	810	160	81	3,135
70	1,400	329	429	36	18	2,212
75	580	31	53	3	3	670
Total	3,345	3,599	2,056	396	522	**9,918**

Table 3
Occupants Associated with the Fatal Crashes by Striking Combination Trucks (>26,000 lbs) from Highway Types of Above Table (FARS 2004-2013)

Speed limit	No Injury	Possible Injury	Not Incapacitating Injury	Incapacitating Injury	Fatal Injury (killed)	Unknown Injury Severity	Died Prior to	Unknown	Total
55	2,830	875	972	831	3,327	34	1	19	8,889
60	740	267	277	221	811	4	0	10	2,330
65	3,253	890	1,058	907	3,120	25	1	26	9,280
70	2,341	735	831	722	2,424	2	1	31	7,087
75	822	165	278	266	730	4	0	9	2,274
Total	9,986	2,932	3,416	2,947	10,412	69	3	95	29,860

Table 4
Striking Single Unit Trucks (>26,000 lbs) involved in Fatal Crashes by Highway Types (FARS 2004-2013)[27]

Speed limit	Rural-Interstate	Rural Principal Arterial Other	Urban Interstate	Urban Freeway / Expressway	Urban Principal	Total
55	9	292	47	32	91	471
60	4	46	22	11	3	86
65	42	87	69	26	5	229
70	45	20	26	8	3	102
75	14	0	1	0	1	16
Total	114	445	165	77	103	904

Table 5
Occupants Associated with the Fatal Crashes by Striking Single Unit Trucks (>26,000 lbs) from Highway Types of Above Table (FARS 2004-2013)

Speed limit	No Injury	Possible Injury	Not Incapacitating Injury	Incapacitating Injury	Fatal Injury (killed)	Unknown Injury Severity	Died Prior to	Unknown	Total
55	369	123	182	138	491	8	0	3	1,314
60	87	27	28	25	89	0	0	1	257
65	298	127	116	92	249	3	0	1	886
70	85	31	44	36	114	0	0	0	310
75	25	5	5	3	15	0	0	0	53
Total	864	313	375	294	958	11	0	5	2,820

Table 6
Striking Buses (>26,000 lbs) involved in Fatal Crashes by Highway Types (FARS 2004-2013)

Speed limit	Rural-Interstate	Rural Principal Arterial Other	Urban Interstate	Urban Freeway / Expressway	Urban Principal	Total
55	5	44	18	8	16	91
60	0	4	11	1	1	17
65	27	16	28	7	1	79

[27] FARS code: 01 for Rural- Interstate, 02 for Rural-Principle Artery, 11 for Urban- Interstate, 12 for Urban-Freeway/Express, 13 for Urban- Principle Artery

70	21	5	11	0	0	37
75	9	1	0	0	0	10
Total	62	70	68	16	18	234

Table 7
Occupants Associated with the Fatal Crashes by Striking Buses (>26,000 lbs) from Highway Types of Above Table (FARS 2004-2013)

Speed limit	No Injury	Possible Injury	Not Incapacitating Injury	Incapacitating Injury	Fatal Injury (killed)	Inj, Sev Unk	Unknown	Total
55	85	207	237	93	112	26	0	760
60	19	8	8	22	12	2	1	72
65	83	295	304	211	113	29	0	1,035
70	92	165	186	70	53	5	0	571
75	10	14	4	17	13	0	0	58
Total	289	689	739	413	303	62	1	2,496

Table 8
Summary of Annual Occupant Fatal Crashes and Fatalities

Speed Limit	Combination Truck		Single Unit Truck		Bus	
	Fatal Crash	Fatality	Fatal Crash	Fatality	Fatal Crash	Fatality
55	313	333	47	49	9	11
60	77	81	9	9	2	1
65	314	312	23	25	8	11
70	221	242	10	11	4	5
75	67	73	2	2	1	1
Total	992	1,041	90	96	23	30

In addition, additional adjustments were made to the target population in the above tables based on the impacts of other safety rules that have been issued since 2009, i.e., the final rule adopting seat belt requirements for passenger seats in buses (78 FR 70415 Nov. 25, 2013) and the electronic stability control requirements for heavy vehicles (80 FR 3650 June 23, 2015).

The final regulatory impact analysis (FRIA) of the lap/shoulder belts for all over-the-road and heavy buses rule (FMVSS No. 208, Docket No. NHTSA-2013-0121) found that lap/shoulder belts would save 1.7 to 9.2 lives (average 5.45 lives) for bus occupants annually (when all driver seats on the covered buses are equipped with lap/shoulder belts with seat belt usage ranges from 50 to 83 percent for drivers, and all passenger seats on the covered buses are equipped with lap/shoulder belts and seat belt usage ranging from 15 percent to 83 percent for passengers). For our benefits model, we need to convert the average 5.45 lives saved from the belt rule into the number of fatal crashes reduced. According to the un-adjusted speed limiter fatal crash data, there are 303 occupant fatalities resulting from 234 fatal bus (GVWR over 26,000 pounds) crashes. This represents an average of 1.29 occupant fatalities per fatal bus crash. Thus we can estimate that the 5.45 fatalities prevented by the belt rule will be associated with the reduction of 4 fatal crashes involving buses annually (5.45 fatalities / 1.29 fatalities per fatal crash) and 40 fatal crashes for a 10-year period.

When the safety belt potential benefits (40) are excluded from the 2004 – 2013 bus target population, it shows 194 buses involved in fatal crashes for those 10 years. When the bus target population is adjusted with the safety belt potential benefit, it results in a 17% reduction in the target population of bus crashes.

Table 9
Fatal Bus Crashes Target population Adjustment

Lives saved		1.7 – 9.2, Avg. 5.45
Crashes involving buses resulting in a fatality from speed limiter target population		234
Fatalities resulting from bus crashes from the speed limiter target population		303
Ratio (fatalities per fatal crash)		1.29
Crashes resulting in a fatality prevented	Per year	4
	For 10 years	40
Crashes involving buses resulting in a fatality from speed limiter target population (Adjusted for safety belt potential benefit)		194
Percent reduction in target population		17%

In addition, the target population of combination trucks was adjusted with the potential benefits of the Electronic Stability Control (ESC) requirements. ESC installed in combination trucks would reduce 40 – 56 percent of un-tripped fatal rollover crashes and 14 percent of fatal loss-of-control (LOC) crashes.[28] The agency analyzed 2004 – 2013 FARS involving combination trucks. For rollover crashes, according to the FARS data, there are 1,251 fatal rollovers among 11,100 total fatal combination truck crashes (with a GVWR of 26k+ lbs). With the 40-56 percent effectiveness in rollover crashes, we assume that on average 600 fatal crashes would be prevented with ESC in rollover crashes ((56% + 40%)/2 = 48%, 48% x 1,251 = 600). For LOC crashes, we used "jackknife" crash as a proxy for LOC crashes. According to the 2004 – 2013 FARS data, there are 772 jackknife crashes and 10,065 non-jackknife crashes. For the 772 jackknife crashes, with the 14% effectiveness, ESC would prevent on average 108 fatal crashes (772 x 14% = 108). Overall, ESC would prevent 708 fatal crashes, 600 lives saved in rollovers and 108 lives saved in lost-of-control crashes (600 + 108 = 709, rounded).[29] When the ESC potential benefits are excluded from the combination truck target population, it leaves 10,391 ($11,100_{\text{fatal rollovers}} – 709_{\text{saved}}$ = 10,391). Therefore, we estimated that 94% of the fatal crashes

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[28] Preliminary Regulatory Impact Analysis (PRIA), FMVSS No. 136, Electronic Stability Control Systems on Truck Tractors and Motorcoaches, NHTSA, August 2011. For large buses, we found that the impact of the proposal on large bus target crashes is negligible, with an extremely small number of target crashes and a projected high ESC installation rate for MY 2012 large buses.
[29] The numbers are rounded to the nearest integer.

would not be affected by ESC (10,391/11,100 = 94%).[30] Accordingly, for ESC, we adjusted the target population with the 94% adjustment factor.

Table 10
Adjusted fatal target population based on FARS, crash and occupant counts
For vehicles with a GVWR greater than 11,793 kg (26,000 lbs.), 10 years, 2004 – 2013

Posted speed, mph	Combination Truck		Single Unit truck		Bus	
	Crash counts	Person counts	Crash counts	Person counts	Crash counts	Person counts*
55	2,933	3,115	217	226	75	93
60	719	759	40	41	14	10
65	2,935	2,921	106	115	65	94
70	2,071	2,269	47	53	31	44
75	627	683	7	7	8	11
total	9,285	9,747	417	442	194	251

* The counts only include vehicle occupants.

Multiple Logistic Regression Model:

In general, the number of fatal crashes in the target population is directly related to two factors: "the risk of having a crash" when a vehicle is on the road and "the risk of fatality" when a crash occurs. There are different factors that affect the risk of having a crash, such as road design, road surface condition and vehicle travel distance. For the benefit estimate, however, we did not separately consider the risk of having a crash on the road. Rather, we focused on the risk of a

[30] Jack_Knife Crashes by Rollover, 2004 – 2013 FARS

JACKKNIFE status	ROLLOVER status No-rollover	rollover	total
Not an articulated vehicle	228	35	263
No	8,912	1,153	10,065
Yes	709	63	772
Total	9,849	1,251	11,100

fatality when a crash occurs.[31] In other words, in the benefit analysis we assumed that the total number of crashes would be the same with or without a speed limiter. This should provide a conservative estimate of safety impacts.

Thus, the focus is on the extent to which the reduction in speed caused by this rule will reduce the severity of the crashes that occur. Although there are several factors that affect the risk of fatality in a crash, the risk generally increases with increased travel speed.[32] Impact force during a crash is related to vehicle speed, and even small increases in speed have large effects on the force of impact. As speed increases, so does the amount of kinetic energy a vehicle has. Because the kinetic energy equation (1/2(mass)(velocity^2)) has a velocity-squared term, the kinetic energy increase is exponential compared to the speed increase, so that even small increases in speed have large effects on kinetic energy. For example, a 5 mph speed increase from 30 mph to 35 mph increases the kinetic energy by one-third: 30^2 equals 900, while 35^2 equals 1225, leading to a 36% increase (1225/900).[33] The effect is particularly relevant for heavier vehicles due to their large mass.[34] Additionally, higher speeds extend the distance necessary to stop a vehicle and reduce the ability of the vehicle, restraint device, and roadway

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[31] For the benefit estimate, we compared fatal crash rates without a speed limiting device to the fatal crash rate with a speed limiting device on roads with a posted speed limits of 55 mph and higher. We note that the approach would somewhat underestimate the potential safety benefit since some of crashes might not occur with the proposed rule.

[32] *See, e.g.*, Johnson, Steven L. & Pawar, Naveen, Mack-Blackwell Rural Transportation Center, College of Engineering, University of Arkansas, Cost-Benefit Evaluation of Large Truck-Automobile Speed Limits Differentials on Rural Interstate Highways, MBTC 2048 (Nov. 2005).

[33] Virginia Commonwealth University Safety Training Center Website, http://www.vcu.edu/cppweb/tstc/crashinvestigation/kinetic.html.

[34] Johnson, Steven L. & Pawar, Naveen, Mack-Blackwell Rural Transportation Center, Cost-Benefit Evaluation of Large Truck-Automobile Speed Limits Differentials on Rural Interstate Highways, MBTC 2048 (Nov. 2005).

hardware such as guardrails, barriers, and impact attenuators to protect vehicle occupants in the event of a crash.[35]

This analysis estimates the lives saved from reducing the severity of heavy vehicle crashes by limiting heavy vehicle travel speeds with a speed limiting device. The three main steps are: (1) the first step was to estimate the travel speeds and risk of fatality on these roads in order to develop a model to predict the risk of fatality as a function of travel speed. As discussed in the later sections; (2) the agencies then broke down the target population of fatal crashes by posted speed limit; (3) finally, we used that model to estimate the lives saved if vehicle travel speeds are limited to a particular speed by a speed limiter.[36]

The basic principle of our model considers the relationship between the number of crashes that result in a fatality and the number of crashes that do not result in a fatality. The mathematical model then evaluates various correlations within the data to see the relationship between travel speed of the heavy vehicle and the crash outcome (fatal or non-fatal). In order to accurately compare crashes that resulted in a fatality and crashes that did not, the agencies used the combination of NHTA's FARS and National Automotive Sampling System (NASS) General Estimates System (GES) databases. FARS includes information on crashes that lead to fatalities,

[35] Liu Cejun & Chen, Chou-Lin, NHTSA, An Analysis of Speeding-Related Crashes: Definitions and the Effects of Road Environments, DOT HS 811 090 (Feb. 2009).

[36] The maximum travel speed of these vehicles would be limited to a particular speed, and we expect that most heavy vehicle drivers would likely travel at or near the maximum allowable speed by the speed limiter. However, some of these trucks may end up traveling below the set speed as a result of the speed limiting devices. Because, in general, the risk of fatal crash would be lower as the travel speed decreases, we may be underestimating the benefit estimates. On the other hand, a vehicle equipped with a speed limiting device could move at a speed slightly higher than the set speed as it goes down the hill, meaning that for some segments of road, this methodology may overestimate benefits.

and, GES includes information on non-fatal crashes. While these two databases lineup with each other in many ways, some information fields are distinctive to each database. As such, in order to properly compare crashes from each database, some crashes that are in the target population could not be considered within the mathematical model, and some adjustments to the GES information must be made.

One issue that the agency needed to resolve is aligning how FARS and GES identify the type of roads on which a crash has occurred. The target population described previously includes function road classes that the agencies believe are similar in terms of basic travel speed patterns such that these crashes are expected to be influenced by the proposed rule. Although both FARS and GES include some information on the type of road on which a crash has occurred, the GES database does not contain the same level of detail as the FARS database. While FARS contains functional road class information including various types of local roads (not included in the target population), as well as rural interstate, rural principal arterial, urban interstate, urban expressway/freeway, and urban principal arterial, GES contains only information with regard to whether the crash occurred on an interstate or not on an interstate (i.e. it does not identify non-interstate roads that may have high speed limits). As such, for the benefits model, the agencies matched only FARS crashes that occurred on rural or urban interstates with GES crashes that occurred on interstates. While the results of the model will be applied to the entire (adjusted) target population presented in the target population section, the model creation includes only fatal crashes that occurred on interstates.

Finally, the model creation does not include the adjustments to the target population described in the target population section resulting from regulations. The impacts of these regulations will be applied after the model has estimated the effectiveness of reducing the travel speed. We are taking this approach as opposed to adjusting both the fatal crashes and the non-fatal crashes prior to the models creation because the opposite approach would require us to exclude certain crashes before applying the effectiveness of speed limiters to the target population. However, we do not have sufficient information to determine which crashes to exclude. We could exclude a randomly determined set of crashes. However, we believe it would be more accurate to adjust for other rulemakings after applying the effectiveness of speed limiters to the crash population.

The assignment of the travel speed at which a crash occurs is critical in considering the ultimate goal of this analysis, which is to establish the relationship between travel speed prior to the crash and the probability of the crash resulting in fatalities. The agencies considered three ways of determining the travel speed of the heavy vehicle prior to the crash: (1) the travel speed of the heavy vehicle as reported in the crash databases (both FARS and GES); (2) the mean speed based upon observational research; or (3) the speed according to the distribution of the observed speeds for each speed zone (or posted speed).

Using the travel speed reported in the heavy vehicle crash databases has two issues that influenced the agencies not to use this data element in our benefits model. First, a large number of crashes in our target population report the travel speed prior to the crash as "unknown or missing" (approximately 60%), meaning that there is simply no data to use. Second, the data appear to be biased toward a particular number, in particular the speed limit of the road. This is understandable: if the actual travel speed was unknown, it might likely be reported as the speed. Considering that this analysis heavily depends on heavy vehicle travel speed, the agencies chose not to use this data element because, when it is available, its resolution is likely not sufficient to determine the benefits of speed limiters accurately.

Instead, the agencies chose to assign the travel speed of each heavy vehicle according to the most likely travel speed using actual observed travel speeds on similar roadways. The agencies made this estimate in two ways. First, the agencies assigned every heavy vehicle the travel speed according to the mean observed travel speeds within each speed zone; and, second the travel speeds were assigned according to the mean and standard deviation profile (within each speed zone). Assigning the mean travel speed to each heavy vehicle has the benefit that no biasing of the data occurs. Since the heavy vehicle travel speed is essentially unknown, assigning the mean observed travel speed represents the most likely average actual travel speed of the heavy vehicle prior to the crash. This approach is limited in that while assigning the mean speed to every heavy vehicle represents the most likely travel speed for that particular crash, it is unlikely that every heavy vehicle involved in a crash is actually traveling at one of the five observed mean travel speeds (one mean observed travel speed for each speed limit of 55, 60, 65, 70, and 75+). In other words, using the mean travel speed in the model implies that all heavy trucks involved in crashes travel at the same (mean) travel speed on a particular posted speed limit road.

The other way we used to assign the travel speed was according to the distribution of observed mean travel speeds and standard deviation. This method more likely represents the range of travel speeds of these vehicles on particular types of roads. However, because the benefit analysis is based upon the ratio of crashes that resulted in a fatality (as the numerator) compared to all crashes (as the denominator), assigning a distribution of speeds the same fatal crash probability regardless of crash speed is contrary to the known properties of the physical world discussed above (that the forces involved in a crash and, thus, likelihood of a crash resulting in a fatality increases with increasing speed). This assumption inherently underestimates the impacts of speed on crash outcome. In other words, based on physics, we expect the mean travel speed in fatal crashes (in the FARS data) would be higher than the mean travel speed in non-fatal crashes (in the GES data), whereas the observed travel speed distribution represents the overall travel speeds.

Considering all these factors, the agencies are reporting multiple model runs that include both assigning each crash the mean speed observed at that speed zone and also runs that include assigning speeds according to the distribution of observed travel speeds.

For the model, we used two types of multivariable regression logistic models, each using two approaches. The considered crash conditions such as type and speed of a heavy vehicle (based upon the above assumptions), number of lanes, and weather condition. We will refer to this method as a "vehicle-based" approach. The second multivariable approach attempts to consider additional potential risk factors for vehicle occupants, such as belt use, age, and seating position and gender, in addition to the crash conditions in the "vehicle-based" approach (or "vehicle-based model"). We will refer to this method as the "person-based" or "occupant-based" approach.

We also used a single variable logistic regression model, focusing on the key risk factor of this research, travel speed. The results for the single variable logistic regression model are not presented in the main body of this analysis. Those results can be found in Appendix A. The results of that analysis falls within the range of estimates developed using the multivariable regression models.

The overall approach for the modeling is shown in Figures 1 and 2.

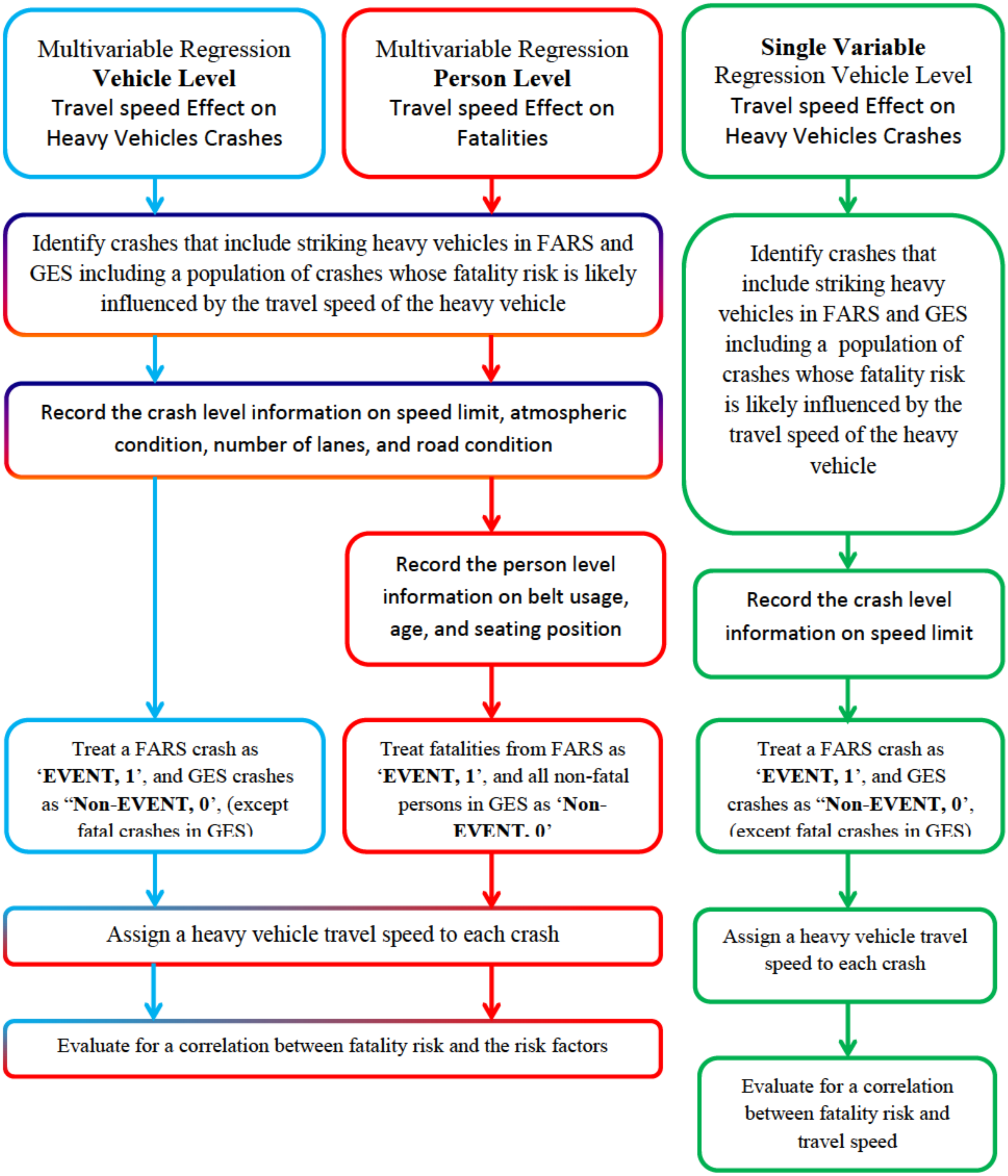

Figure 1 Overall Approach for Modeling

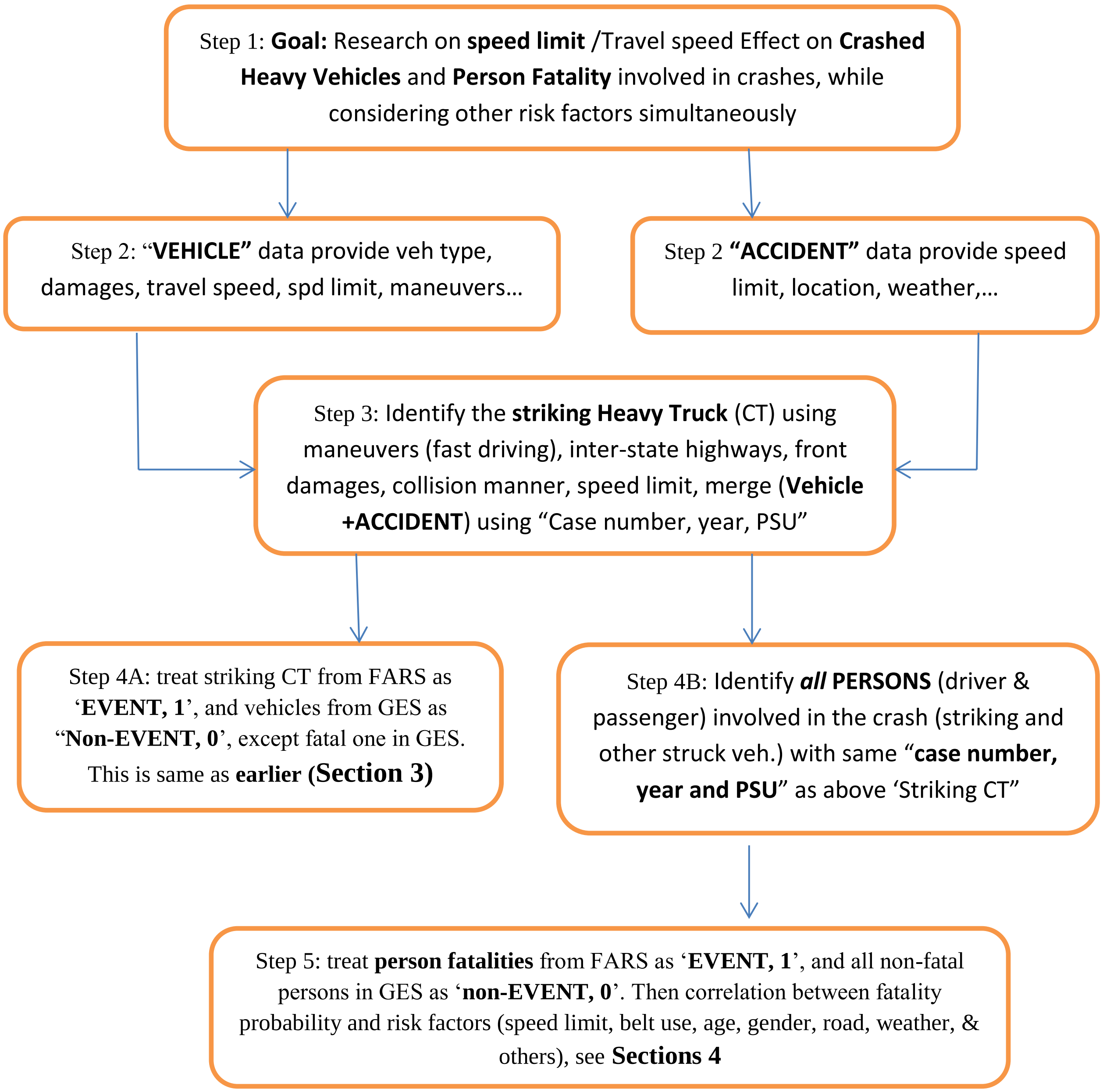

Figure 2 Data Flowchart used for Vehicle based and Person-based Approaches

As shown in the flow charts, vehicle and accident data are used to identify the striking heavy vehicle (such as combination trucks). In addition, vehicle maneuvers (such as straight driving, on inter-state highways with front damages), speed limit, and road conditions are used to identify the striking heavy vehicle. All occupants involved in a crash were identified by linking the crash case number, year, and Primary Sample Unit (PSU) with the striking vehicle. Thereafter, a multiple logit model is used to link the binary outcome (1, 0, fatal or not) with the possible risk factors that include speed limit, travel speed, vehicle type, occupant age, seating, belt use, road conditions, weather and more.[37] (See Appendix F for additional discussion and the SAS codes used for the analyses.)

B. Vehicle-Based Model.

In this approach, the risk of a crash resulting in a fatality (fatal crash rate) was derived by dividing the number of striking heavy vehicles involved in fatal crashes in FARS by the number of striking heavy vehicles involved in GES for each posted speed zone.[38]

$$fatal\ vehicle\ rate = \frac{Striking\ Vehicles\ involved\ in\ fatal\ crashes\ in\ FARS}{nonfatally\ crashed\ vehicles\ in\ GES + Striking\ Vehicles\ involved\ in\ fatal\ crashes\ in\ FARS}$$

Eq. (1)

[37] In addition to the multivariable regression, as discussed previously, we considered a single variable regression that focused on the impact of travel speed alone on the crash outcome. See Appendix A for discussion of the single variable regression.

[38] The crash type criteria are the same for the FARS (numerator) and GES (denominator) data. We did not investigate any differences in the type of vehicles being struck for the fatal and non-fatal crashes.

Table 11
Risk of fatal combination truck in crashes by posted speed limit
FARS/GES Vehicle Ratio during 2004-2013, Interstate only[39]

Speed limit	vehicles involved in fatal crashes (FARS)	All vehicles (non-fatal GES and fatal, FARS)
55	722	36,168
60	364	19,786
65	1,889	36,204
70	1,854	33,299
75	641	16,738

For the multivariable vehicle-based model, we considered three factors – speed, number of lanes (road with 3-7 lanes is compared with the road with only 1-2 lanes) and road condition (good road surface is compared with the poor surface conditions of wet, or icy road surface). As discussed, the crash data were grouped by posted speed limit, 55 - 75 mph. The crash data in the model came from the highway types of "rural-interstate, or urban interstate highways (FARS, road_FNC =1, 11)" and "interstate highway (GES, int_hwy=1)".

The multiple logistic model is used to fit the crash data from FARS & GES 2004-2013 and to correlate the 'input risk factors' and 'outcome variable' (see following Figure and Eq. (2)), in which the outcome variable is whether a heavy vehicle is involved in fatal crash or not, and is treated as binary variable (1, 0), with the fatal crashes from FARS data (2004-2013) as the 'event, 1' while the non-fatal crashes from GES data (2004-2013) as 'not-event, 0'.[40] The logit

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[39] In the regression analysis, only inter-state highways (1,11) are used from FARS since GES only have a reattribute for interstate. We note that the target populations used all five rode types, Rural- & Urban Interstate, Rural- & Urban Principle Artery, and Express.

[40] We note that the fatal crashes or occupant fatalities from FARS are census data on the other hand non-fatal crashes from GES are survey data with sampling weights. It is challenging to describe and interpret the similar vehicle crashes consistently using the variables from two different databases. In addition, similar variables from

model predicts a fatal crash probability which is between 0 and 1, and the input risk factors in the logit model include several key factors that may contribute to fatal crash – such as speed limits or travel speeds (travel speeds have more practical meanings for describing crash severity since vehicles travel with very different speeds even in the same speed limit zone), road lane numbers, road surface conditions, and weather. The logit model explores the relative risk or odds ratio of a heavy vehicle being involved in a fatal crash, by comparing higher speed with lower speed (1 mile, or 5 mile gap for the speed limit analysis), by comparing poor/wet/icy road conditions with a dry one, etc. In following Eq. (2), 'p' stands for the probability of 'vehicle involved in fatal crash', '1-p' stands for the probability of 'not-fatally crashed', and 'p/(1-p)' is the 'odds' of the 'fatally crashed vehicle' versus 'not-fatally crashed vehicle'. One of key interests in this analysis is to obtain the 'ratio of odds' of higher speed versus lower speed, or 'Odds Ratio (OR)'. Regression coefficient, β_i (i=1,2,3,..n), is termed as 'log odds ratio' of predictor or risk factor (X_i, such as speed), i.e., 'odds ratio (OR)' of any risk predictor (X_i) is from $e^{\beta i}$. The OR value of larger than 1.0 indicates the higher chance of a vehicle involved in a fatal crash while less than 1.0 indicates a lower chance.

The numerical results include the mean values of odds ratios and 95% confidence intervals of odds ratios. The interpretations of these odds ratios are, therefore, always relative to the

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FARS and GES may have different missing rates or slightly different interpretations. Although the regression model would generate accurate means of odds ratios for relative comparisons, prediction of standard deviations or variances of the odds ratio would be challenging when compared to a simpler model (that is based on either FARS or GES).

associated conditions, e.g., the fatal crash odds of higher speed versus lower speed, or wet/icy road versus dry road. The results are categorized by vehicle types of combination truck, single unit truck, and bus, respectively. The calculation results, using '*proc FREQ*' and '*proc SurveyLogistic*', from SAS Institute, are listed based on Eq. (2) or Eq. (2b).

$$p(vehicle\ of\ fatal\ crash) = \frac{\exp(\beta_0+\beta_1 speed+\ \beta_2 weather+\beta_3\ Lane_{numb}+\ \beta_4\ road\_surf)}{1+\exp(\beta_0+\beta_1 speed+\ \beta_2 weather+\beta_3\ Lane_{numb}+\ \beta_4\ road\_Surf)} \qquad \text{Eq. (2)}$$

Eq. (2) can be re-arranged so that the right side of equation has a linear form, as Eq. (2B)

$$ln(\frac{p}{1-p}) = \beta_0 + \beta_1 speed + \ \beta_2 weather + \beta_3\ Lane_{numb} + \ \beta_4\ road\_surf \qquad \text{Eq.(2b)}$$

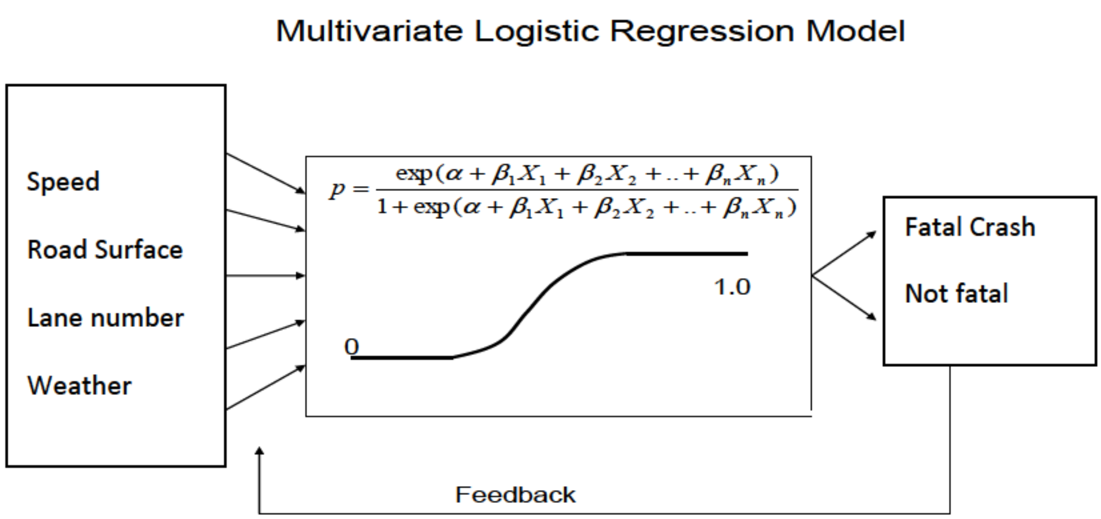

Figure 3: Multiple Logit Model to Link 'Input Risk Factors (speed and others) to the 'Outcome (Fatal Crash of Heavy Vehicle)'

There are certain challenges or limitations of using both FARS and GES in the calculations, since the fatal crashes or occupant fatalities from FARS are census data, on the other hand, non-fatal crashes from GES are survey data with sampling weights, and GES data are collected from sixty primary sampling units (PSU) across US. FARS data have no information of PSU or weights. It is more challenging to describe and interpret the similar vehicle crashes consistently using the variables from two different databases, and the similar variables from FARS and GES may also have different missing rates or slightly different interpretations.

a. Combination Trucks

B.a.i. Combination trucks vehicle-based model with speed distribution:

In order to determine the appropriate travel speed distribution, we first estimated the heavy vehicle travel speeds based on the speeds observed on 20 rural interstate highways in 13 states.[41]

Table 12
Heavy truck observed average speeds on rural highways

State	Posted speed (mph)	Sample size	Observed Speed (mph)	Std. Dev. (mph)
California	55	277	61.2	3.62
Illinois	55	262	64.2	4.00
Oregon	55	273	60.9	2.87
Washington	60	139	63.3	3.04
Washington	60	154	64.5	2.67
Washington	60	246	62.9	3.28
Connecticut	65	184	66.4	3.80
Connecticut	65	156	66.0	3.16
Connecticut	65	212	66.1	3.44
South Carolina	65	433	67.2	4.12
Arkansas	65	169	66.7	3.69
South Carolina	70	276	69.0	4.00

[41] Johnson, S. & Murray D., Empirical Analysis of Truck and Automobile Speeds on Rural Interstates: Impact of Posted Speed Limits, July 2009; Johnson, Steven L. & Pawar, Naveen, Mack-Blackwell Rural Transportation Center, College of Engineering, University of Arkansas, Cost-Benefit Evaluation of Large Truck-Automobile Speed Limits Differentials on Rural Interstate Highways, MBTC 2048 (Nov. 2005).

Missouri	70	247	68.6	4.55
Texas	70	131	68.6	3.63
Oklahoma	70	168	69.4	3.38
New Mexico	75	36	68.9	5.97
New Mexico	75	276	68.0	4.20
Oklahoma	75	33	72.3	5.63
South Dakota	75	193	67.0	4.00
Wyoming	75	140	69.8	4.85

Table 13
Average Travel Speeds for Heavy Vehicle, mph

Posted speed Limit	Avg	Std Dev.
55.0	62.06712	3.522842
60.0	63.4603	3.054976
65.0	66.63492	3.766994
70.0	68.89781	4.003561
75.0	68.3441	4.47854

Table 14
Distribution of Heavy Vehicle Miles Traveled (VMT) Based on Average Travel Speed Distributions

Travel Speed	Posted Speed				
	55 MPH	60 MPH	65 MPH	70 MPH	75 MPH
45	0.00000091	0.00000000	0.00000001	0.00000000	0.00000011
46	0.00000344	0.00000001	0.00000003	0.00000001	0.00000035
47	0.00001207	0.00000006	0.00000013	0.00000003	0.00000104
48	0.00003905	0.00000036	0.00000051	0.00000012	0.00000294
49	0.00011651	0.00000178	0.00000184	0.00000043	0.00000792
50	0.00032074	0.00000795	0.00000617	0.00000145	0.00002026
51	0.00081460	0.00003188	0.00001924	0.00000456	0.00004932
52	0.00190868	0.00011483	0.00005590	0.00001349	0.00011422
53	0.00412599	0.00037161	0.00015136	0.00003754	0.00025166
54	0.00822865	0.00108038	0.00038194	0.00009810	0.00052750
55	0.01514032	0.00282186	0.00089822	0.00024086	0.00105192
56	0.02570083	0.00662153	0.00196866	0.00055562	0.00199568
57	0.04024990	0.01395878	0.00402116	0.00120420	0.00360203
58	0.05815515	0.02643644	0.00765467	0.00245202	0.00618517
59	0.07752062	0.04498052	0.01357991	0.00469087	0.01010421
60	0.09533489	0.06875627	0.02245238	0.00843119	0.01570366
61	0.10816635	0.09442049	0.03459573	0.01423733	0.02321916
62	0.11322390	0.11648940	0.04967954	0.02258776	0.03266176

63	0.10934268	0.12911381	0.06648558	0.03366842	0.04370991
64	0.09741973	0.12856571	0.08292247	0.04714951	0.05565031
65	0.08007737	0.11501216	0.09638553	0.06203494	0.06740664
66	0.06072650	0.09243332	0.10441101	0.07668325	0.07767567
67	0.04248664	0.06673897	0.10540849	0.08905730	0.08515589
68	0.02742409	0.04329090	0.09917444	0.09717250	0.08881610
69	0.01633118	0.02522783	0.08695985	0.09961439	0.08812844
70	0.00897240	0.01320777	0.07106122	0.09594132	0.08319319
71	0.00454784	0.00621219	0.05411795	0.08681487	0.07471483
72	0.00212671	0.00262499	0.03841005	0.07380528	0.06383710
73	0.00091752	0.00099649	0.02540641	0.05895025	0.05189038
74	0.00036520	0.00033985	0.01566162	0.04423731	0.04012803
75	0.00013411	0.00010413	0.00899756	0.03118865	0.02952271
76	0.00004543	0.00002866	0.00481735	0.02065900	0.02066388
77	0.00001420	0.00000709	0.00240373	0.01285663	0.01375989
78	0.00000409	0.00000157	0.00111779	0.00751709	0.00871696
79	0.00000109	0.00000031	0.00048442	0.00412930	0.00525367
80	0.00000027	0.00000006	0.00019565	0.00213113	0.00301237
81	0.00000006	0.00000001	0.00007365	0.00103335	0.00164324
82	0.00000001	0.00000000	0.00002583	0.00047075	0.00085279
83	0.00000000	0.00000000	0.00000845	0.00020148	0.00042104
84	0.00000000	0.00000000	0.00000257	0.00008102	0.00019777
85	0.00000000	0.00000000	0.00000073	0.00003061	0.00008838

The above VMT data (with means and standard deviations) at each speed limit observed from field could be simulated by a Gaussian normal distribution, as following Figure.

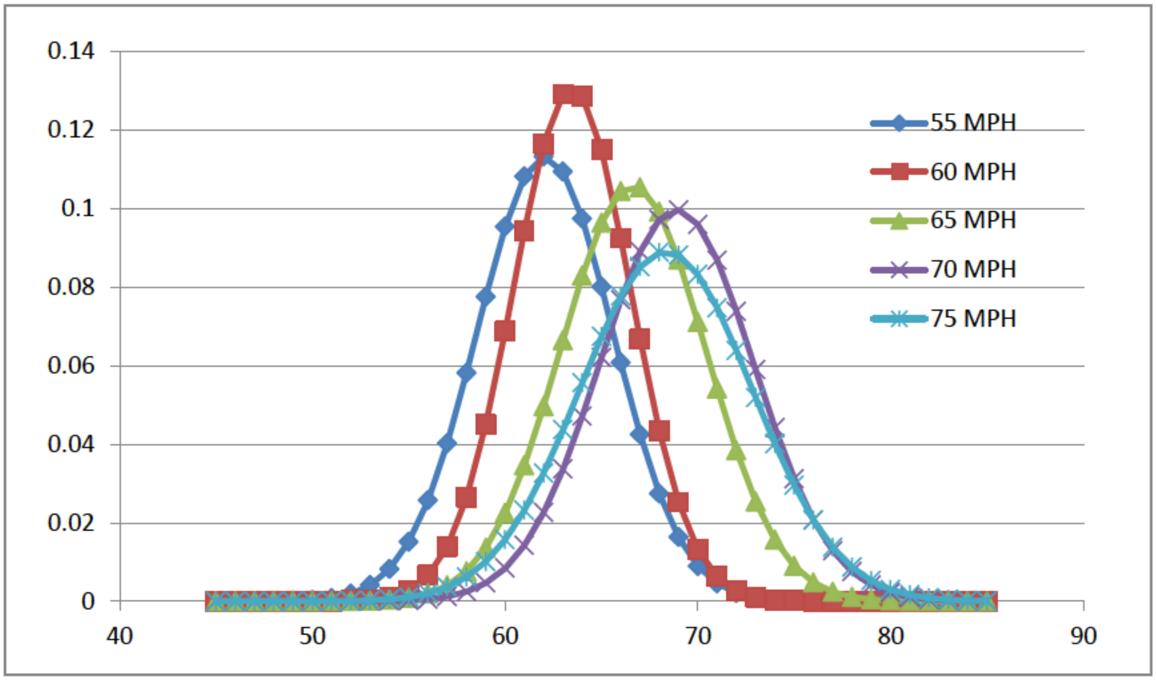

Figure 4: Five Normal Distributions of VMT based on Field Observation Data (Travel Speed Means & Standard Deviations at Each Speed Limit)

As we discussed earlier that travel speed profile came from the field tests and observations at each post speed limit of 55, 60, 65, 70 and 75 MPH, respectively, the logit model used these speed limits first in order to estimate the impact of speed limits on the odds of fatal crashes. It is found that the odds ratio, for each additional 5 miles of speed limit (e.g., 65 MPH versus 60 MPH), is 1.246 (95% CI = 1.081 to 1.438), if the speed limit is considered only. However, the travel speeds within any speed limit zone could be widely distributed, which could be simulated by a Gaussian normal distribution as above Figure 4 based on the field observation data, and only the travel speed reflected the true crash severity.

For each crash on a particular posted speed road (such as 70 mph roads), we selected a travel speed of a combination truck based on the travel distribution that is applicable to the posted speed road (for example, 70 mph). We repeated the process until all crashes are accounted for. The results from the multivariable logistic regression show that the risk of fatal crash would increase by 1.047 when the speed of a combination truck is increased by one mile per hour (mph).[42] The 1.047 odds ratio is statistically significant with a p-value <5%

Table 15
Combination trucks, vehicle-based modeling with travel speed distribution, Maximum Likelihood Estimates, per each mile

Analysis of Maximum Likelihood Estimates					
Parameter	**DF**	**β Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Intercept	1	-6.1150	0.9689	39.8345	<.0001
Higher speed (1 mile)	1	0.0459	0.0149	9.4356	0.0021
Wet/icy road Surf. vs. Dry	1	0.3147	0.1465	4.6161	0.0317
Lane Numb. > 2 vs. less	1	-0.2014	0.2082	0.9358	0.3334

* The value is statistically significant with p-value <5%

The 'estimate', or 'β_i ' from above table can be applied to Eq. (2) to predict the probability of a heavy vehicle involved in a fatal crash.

Table 16
Combination trucks, vehicle-based modeling with travel speed distribution, Odds Ratio Estimates, per each mile

Odds Ratio Estimates			
Effect	**Point Estimate**	**95% Wald Confidence Limits**	
Higher speed (1 mile)	1.047*	1.017	1.078
Wet/icy road Surf. vs. Dry	1.370	1.028	1.825
Lane Numb. > 2 vs. less	0.818	0.544	1.230

* The value is statistically significant with p-value <5%

The ***interpretations*** of the above odds ratios are that a combination truck traveling at a higher speed (by 1 mile) had approximately 4.7% higher risk (or 4.7% more likely) of being involved in

[42] The SAS codes used for the analysis are provided in Appendix H

a fatal crash than the lower speed vehicle (significant with p-value under 5%). Poor road surface conditions (wet, icy, .etc.) would result in approximately 37% higher risk of fatal crash incidents, or 37% more likely to cause some fatal crashes (significant with p-value under 5%), while lane number is not a significant factor (p-value=0.333, much larger than 0.05 marginal value), and roads with 3-4 lanes may have similar risk as roads of 1-2 lanes.

B.a.ii. Using **mean travel speeds**, combination trucks, vehicle-based model:

Next, we conducted a vehicle-based multivariable logistic regression with the mean combination truck speeds, e.g., only five mean values, 62.07, 63.46, 66.63, 68.90, and 68.34 mph, from the original five normal distributions are used to represent the travel speeds of the five speed limit zones of 55, 60, 65, 70 and 75 MPH, respectively. As a result, the range of the travel speeds now is between 62.07 and 68.90, which is much narrower than the range under the distribution, and the fatality rate would change much more rapidly within such a narrow speed range. The results of the modeling show that the risk of a fatal crash is higher for higher speed versus lower, and increase by 1.154 when the speed of a combination truck is increased by one mile per hour (mph). The 1.154 odds ratio (OR) is statistically significant with p-value <5%, and this OR value shows a higher fatality rate changing trend due to a narrower speed range.

Table 17
Combination trucks, vehicle-based model with mean travel speeds,
Maximum Likelihood Estimates for each mile interval

Analysis of Maximum Likelihood Estimates					
Parameter	**DF**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Intercept	1	-12.6516	3.8174	10.9839	0.0009

Analysis of Maximum Likelihood Estimates					
Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Higher travel speed (1 mile)	1	0.1428	0.0578	6.1086	0.0135
Wet/icy road surf. vs. Dry	1	0.3613	0.1472	6.0259	0.0141
Lane numbers >2 vs. Less	1	-0.0166	0.1929	0.0074	0.9314

Table 18
Odds Ratios (Combination Truck) of Two Relative Condition Comparison

Odds Ratio Estimates			
Effect	Point Estimate	95% Wald Confidence Limits	
Higher travel speed (1 mile)	1.154*	1.030	1.292
Wet/icy road surf. vs. Dry	1.435	1.076	1.915
Lane numbers >2 vs. Less	0.984	0.674	1.436

The ***interpretation*** of the above odds ratios is that a heavy vehicle (CT) traveling at higher speed (1 mph) had approximately 15% higher risk of being involved in a fatal crash than the lower speed vehicle (significant with p-value under 5%).

b. SUTs

B.b.i. **SUT** vehicle-based multivariable model with speed distributions:

Single unit trucks (SUTs) had small sample sizes, which made it challenging to use a multiple regression to describe the relative risk of fatal crashes. For SUTs, similar to the approach used for combination trucks, we conducted a vehicle based multivariable logistic regression with the truck speed distribution. The small sample sizes produced a nonsignificant comparison of the fatal crash odds between higher speed and lower one, when the travel speed profile based on the five normal distributions were used (i.e., 1 mile gap).

Table 19
SUTs, vehicle-based model with travel speed distribution,
Maximum Likelihood Estimates for each mile interval

Analysis of Maximum Likelihood Estimates					
Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	-4.3968	1.6472	7.1246	0.0076
Higher Speed (1)	1	0.0142	0.0253	0.3160	0.5740
Wet road surf. vs. Dry	1	-0.6724	0.2601	6.6843	0.0097
Lane numb >2	1	-0.7289	0.2491	8.5647	0.0034

Table 20
SUTs, vehicle-based model with travel speed distribution,
Odds Ratio Estimates, for each mile interval

Odds Ratio Estimates			
Effect	Point Estimate	95% Wald Confidence Limits	
Higher Speed (1)	1.014	0.965	1.066
Wet road surf. vs. Dry	0.510	0.307	0.850
Lane numb >2	0.482	0.296	0.786

Interpretations: The small sample size of single unit truck produces a non-significant comparison between lower and higher speed fatalities, e.g., OR = 1.014 with a p-value of 0.57. Small sample size can make it challenging when comparing the fatality rates of two different conditions, especially if multiple variables are included.

<u>B.b.ii SUTs, vehicle-based multivariable model with the mean travel speed:</u>

We conducted a vehicle based multivariable logistic regression with the truck mean travel speed. The results of the modeling show that the risk of fatal crash would increase by 1.079 when the speed of a SUT is increased by one mile per hour. The 1.079 odds ratio is statistically insignificant.

Table 21
SUTs, vehicle-based modeling with the mean travel speed,
Maximum Likelihood Estimates for each mile interval

Analysis of Maximum Likelihood Estimates					
Parameter	**DF**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Intercept	1	-8.5578	4.2484	4.0577	0.0440
Higher Speed (1)	1	0.0765	0.0646	1.4015	0.2365
Wet road surf. vs. Dry	1	-0.7010	0.2655	6.9696	0.0083
Lane numb >2	1	-0.6345	0.2623	5.8510	0.0156

Table 22
SUTs, vehicle-based modeling with 5 means of travel speed,
Odds Ratio Estimates, for each mile interval

Odds Ratio Estimates			
Effect	**Point Estimate**	**95% Wald Confidence Limits**	
Higher Speed (1),	1.079	0.951	1.225
Wet road surf. vs. Dry	0.496	0.295	0.835
Lane numb >2	0.530	0.317	0.887

Interpretations: The small sample size of single unit truck produces a non-significant comparison between lower and higher speed fatalities, e.g., OR = 1.079 but with a p-value of 0.24.

c. Buses

B.c.i **Buses** vehicle-based multivariable model with travel speed distribution:

For bus crashes, the sample size is too small to perform a reliable multiple regression analysis. The following four tables display the vehicle-based results for bus crashes.

First, we consider the case of only travel speed is available in vehicle-based model since the sample size is small and p-value is over 5%.

Table 23
Bus - vehicle-based model with travel speed distribution,
Maximum Likelihood Estimates for each mile interval

Analysis of Maximum Likelihood Estimates					
Parameter	**DF**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Intercept	1	-2.5670	3.8184	0.4520	0.5014
Higher Speed (1)	1	-0.00428	0.0604	0.0050	0.9435
Wet road surf. vs. Dry	1	-0.9397	0.7917	1.4090	0.2352
Lane numb >2	1	-0.7590	0.5455	1.9361	0.1641

Table 24
Bus vehicle-based model with travel speed distribution,
Maximum Likelihood Estimates for each mile interval

Odds Ratio Estimates, 5 distributions			
Effect	**Point Estimate**	**95% Wald Confidence Limits**	
Higher Speed (1)	0.996	0.885	1.121
Wet road surf. vs. Dry	0.391	0.083	1.844
Lane numb >2	0.468	0.161	1.364

Table 25
Bus, vehicle-based modeling with 5 means of travel speed,
Odds Ratio Estimates, for each mile interval

Analysis of Maximum Likelihood Estimates, 5 means					
Parameter	**DF**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Intercept	1	-8.1371	7.0677	1.3255	0.2496
Higher Speed (1)	1	0.0776	0.1100	0.4970	0.4808
Wet road surf. vs. Dry	1	-0.6667	0.6095	1.1966	0.2740
Lane numb >2	1	-0.5560	0.5359	1.0764	0.2995

Table 26
Bus Odds Ratio (5 means)

Odds Ratio Estimates, 5 means

Effect	Point Estimate	95% Wald Confidence Limits	
Higher Speed (1)	1.081	0.871	1.341
Wet road surf. vs. Dry	0.513	0.155	1.695
Lane numb >2	0.573	0.201	1.639

In summary, the vehicle-based model shows that the odds ratio for combination trucks ranges from 1.047 to 1.154 for each mile per hour. In addition, the odds ratio for SUTs and buses ranges from 1.014 to 1.079 and 0.996 to 1.081, respectively. The odds ratios derived with different approaches for combination trucks are summarized below.

Table 27
Vehicle-based Odds Ratios for Combination Trucks, SUTs and Buses, for each mile

Vehicle Type	With speed distribution	With mean speed
Combination Truck	1.047*	1.154*
SUT	1.014	1.079
BUS	0.996	1.081

* Statistically significant

C. Occupant-based Model

In addition to the "vehicle-based" model, we considered another model with addition variables based on occupant fatality status, which is used to correlate the 'input risk factors' and 'outcome variable' in the analysis. The outcome variable is whether an occupant (driver or passenger) was killed in a crash or not.

$$person\ fatality\ rate = \frac{Fatal\ occupants\ from\ crashes\ by\ striking\ vehicles\ in\ FARS}{nonfatal\ occupants\ of\ similar\ veh.in\ GES + fatal\ occupants\ from\ vehicles\ in\ FARS}$$

Eq. (3)

The outcome variable is treated as binary variable (1, 0) where the fatal occupants from FARS data (2004-2013) are treated as the 'event, 1' while not-fatal occupants from GES data (2004-

2013) as ‘not-event, 0’. The logit model predicts such fatality probability, which is between 0 and 1. The input risk factors in the vehicle-based logit model include the key factors (speed limits, travel speeds, lane numbers, and road surface conditions) that may contribute to fatal crash included in the “vehicle-based” model and other factors focused on the occupants (belt use status, occupant gender, age, and seating position (see following Eq. (4), and Figure. In Eq. (4), ‘p’ stands for the probability of ‘a person being fatal’, ‘1-p’ stands for the probability of ‘not-fatal’, and ‘p/(1-p)’ is the ‘odds’ of the ‘fatal person’ versus ‘not-fatal persons’. The logit model explores the relative risk or odds ratio of an occupant fatality, for example, by comparing higher speed with lower speed, or by comparing poor/wet/icy road surface conditions with dry one, etc. The key results are mean values of odds ratios and 95% confidence intervals of odds ratios. The interpretations of these odds ratios are, therefore, always relative to the associated conditions, e.g., the occupant fatal odds of higher speed versus lower speed, or wet/icy road versus dry road. The occupant-based model is similar to the earlier vehicle-based logit model, with additional factors from occupants.

$$p(person\ fatality) = \frac{\exp(\beta_0+\beta_1 speed+\ \beta_2 belt+\beta_3\ age+\beta_4 seating+\beta_5\ road_{surf}+\ \beta_6 Gender+\beta_7 Lane\_Num)}{1+\ \exp(\beta_0+\beta_1 speed+\ \beta_2 belt+\beta_3\ age+\beta_4 seating+\ \beta_5\ road_{surf}+\ \beta_6 Gender\ \ +\beta_7 Lane\_Num)}$$

Eq. (4)

Eq. (4) can be re-arranged so that the right side of equation has a linear form, as Eq. (4B)

$$\ln(\frac{p}{1-p}) =$$

$$\beta_0 + \beta_1 speed +\ \beta_2 belt + \beta_3\ age + \beta_4 seating + \beta_5\ road_{surf} +\ \beta_6 Gender+\beta_7 Lane\_Num$$

Eq. (4b)

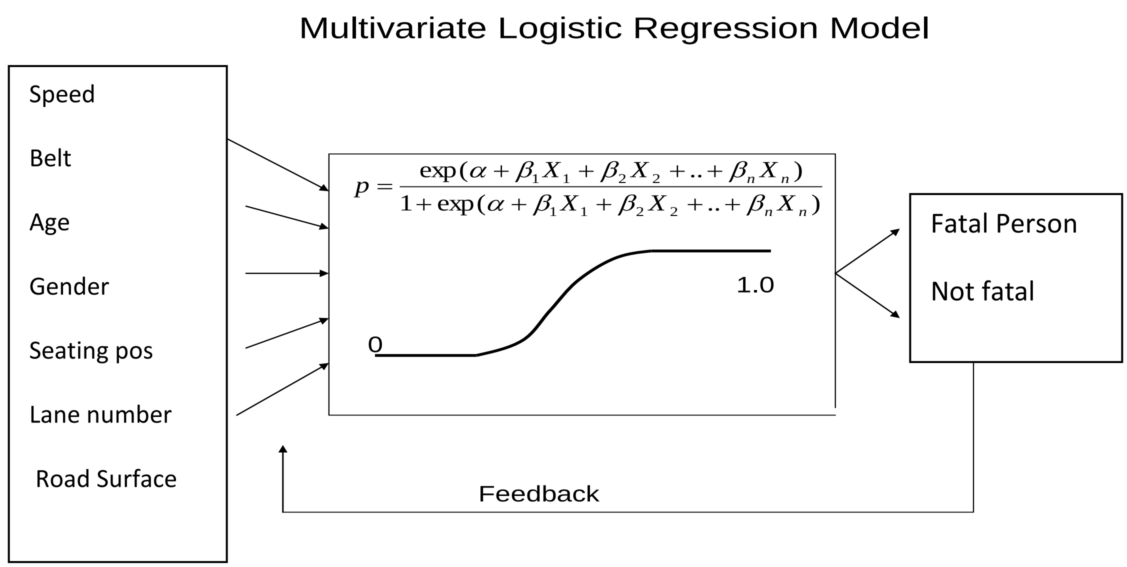

Figure 5 Person-based multivariable logistic regression model

C.a.i. Combination trucks, multivariable person-based model with a travel speed distribution, with adjusted seat belt use rate:

Table 28

Combination trucks, fatal person (driver and passenger) and injured, FARS/GES (2004-2013)[43]

Speed limit	Fatalities from FARS	all persons (GES nonfatal, FARS fatal)
55	671	90,597
60	352	56,693
65	1736	88,858
70	1,997	82,544
75	685	44,828

[43] In the regression analysis, only inter-state highways (1,11) are used from FARS since GES only includes an attribute for interstate.

The results from the person-based regression with the travel speed distribution showed that the risk of fatality would increase by 1.033 when the speed of a combination truck is increased by one mile per hour (mph). Although the 1.033 odds ratio is statistically significant, the GES data show a relatively high belt use rate of over 90%, as further discussed below.

Seat belt use is an important control variable because seat belts improve the chance of survival in a potentially fatal crash by roughly 50%. However, police-reported belt use rates in GES are known to be significantly inflated because survivors in primary belt law states have an incentive to claim belt use in order to avoid fines or contributory negligence in the case of litigation. Evidence of this overstatement is apparent when belt use is compared from different data sources. In GES, for the cases examined in this study, claimed known belt use among all occupants was 97%. This compares to the observed daytime belt use derived from NOPUS during this same timeframe of 83.4%.[44] NOPUS is an observational survey and it is difficult for roadside observers to observe belt use after dark. However, we know from crash databases that seat belt use is lower after dark. Often this lower use corresponds with alcohol or drug use, particularly on weekend evenings. The daytime NOPUS observed use rate is thus higher than the use rate that would be expected across all 24 hours.

To estimate the 24 hour equivalent belt use rate, we compared the belt use rates from NASS Crashworthiness Data System (CDS) during the "daytime" timeframe when NOPUS surveys are conducted (7:00 AM- 5:59 PM) to use rates in all other hours. Nighttime use rates were found to

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[44] http://www-nrd.nhtsa.dot.gov/Pubs/812243.pdf

be roughly 15 points lower than daytime rates. CDS data may also be subject to false belt use claims. The daytime use rate for CDS Heavy Truck crash cases was 93% compared to observational survey data indicating an 83% daytime usage rate. Because it is based on unbiased observations, we assume NOPUS is the most accurate estimate of daytime use in the vehicle occupant population. Although the absolute CDS use rates are inflated, we have no evidence that the rate of overstatement is different in daytime vs. nighttime. We thus assume the ratio of CDS nighttime to daytime use provides a reasonable estimate of the relative use rates by time of day. Applying this ratio to the daytime NOPUS use rate gives an estimated nighttime use rate of roughly 70%. We then used the relative incidence of daytime and nighttime crashes in GES to weight the seat belt use rates, producing an overall 24 hour use rate of 80%. Adjusting for the 6% of GES cases with unknown belt use, this implies a corrected GES "YES" belt use response of 75%. Furthermore, the current model utilizes both GES and FARS data, and the belt rate adjustment is applied to non-fatal occupants of GES data only, the belt use rate of fatal occupants of FARS would remain the same, as Eq. (3) indicates. This process is illustrated in Table 29 below.

Table 29
Estimated Corrected GES Seat Belt Use Rate

Belt use data source	Usage	GES % Incidence	Aggregate Usage
2004-2013 CDS Known Daytime Seat Belt Use Rate Excluding Fatalities	92.96%	n/a	n/a
2004-2013 CDS Known Nighttime Seat Belt Use Rate Excluding Fatalities	77.49%	n/a	n/a
Nighttime/Daytime Use Rate	83.36%	n/a	n/a
Average NOPUS daytime usage 2004-2013	83.43%	75.70%	63.16%
Estimated Nighttime usage	69.55%	24.30%	16.90%
Estimated observed daytime plus nighttime use rate	n/a	n/a	80.06%
% Unknown belt use from GES Heavy Truck Crashes 2004-2013	n/a	n/a	6.00%
% Known belt use from GES Heavy Truck Crashes	n/a	n/a	94.00%

2004-2013			
Implied YES belt use in GES Heavy Truck Crashes 2004-2013	n/a	n/a	75.25%

In order to reflect this correction, we randomly selected cases where belt use was claimed and changed the belt use coding to "not used." The re-coding was applied to enough cases to shift the claimed belt use rate among all cases in the data base to 75%. Several iterations of this process were attempted, and it was found that the specific cases that were randomly selected did not significantly affect the results. The results from the person-based regression with the adjusted seat belt use rate showed that the risk of fatality would increase by 1.026 when the speed of a combination truck is increased by one mile per hour (mph). We note that the 1.026 odds ratio is not statistically significant (p-value =0.12). As discussed in the following section, we decided not to use the odds ratio in the benefit estimate since the model with the adjusted seat belt use rate resulted in a statistically nonsignificant odds ratio.

Table 30
Combination truck, Person-based multivariable logistic regression with adjusted belt use rate (75%), with speed distribution, Maximum Likelihood Estimates

Analysis of Maximum Likelihood Estimates					
Parameter	**DF**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Intercept	1	-5.8961	1.4505	16.5229	<.0001
Higher travel speed (1)	1	0.0253	0.0162	2.4439	0.1180
Non-belted /belted	1	0.8079	0.0537	226.2398	<.0001
AGE	1	-0.00268	0.000406	43.5568	<.0001
Female /male	1	0.4694	0.0797	34.7164	<.0001
Front seating	1	-0.1474	0.1966	0.5624	0.4533
Lane numbers >2	1	-0.3809	0.3554	1.1488	0.2838
Wet/icy Road Surf. vs. Dry	1	0.5703	0.2115	7.2743	0.0070

Table 31
Combination truck, Person-based multivariable logistic regression with adjusted belt use rate (75%), with speed distribution, Odds Ratio Estimates

Odds Ratio Estimates			
Effect	**Point Estimate**	**95% Wald Confidence Limits**	
Higher travel speed (1)	1.026	0.994	1.059
Non-belted /belted	2.243	2.019	2.492
AGE	0.997	0.997	0.998
Female /male	1.599	1.368	1.869
Front seating	0.863	0.587	1.269
Lane numbers >2	0.683	0.340	1.371
Wet/icy Road Surf. vs. Dry	1.769	1.169	2.677

The ***interpretation*** of the above odds ratios are that a combination truck traveling at higher speeds (by 1 mile) had approximately 2.6% higher fatality than the lower speed vehicle (non-significant with p-value over 5%); especially and significantly non-belted occupants had more than twice odds of being killed than the belted; females also had 59% higher risk than males. It shows that some factors such as road surface are not statistically significant.

With the 75% adjusted seat belt use rate, the combination truck person-based multivariable model with a travel speed distribution showed an odds ratio of 1.026. However, as noted, the 1.026 odds ratio is not statistically significant and is reduced relative to the unadjusted belt use model. It appears the random assignment process of the adjustment affected the covariance between speed and seat belt use in a manner that attenuated the covariance of fatality risk and the residual variance in speed. While the adjustment on belt use would theoretically improve the accuracy of the estimated coefficient on seatbelt use, there is no reason to believe it has improved the covariance between speed and seatbelt use. If the adjustment introduced random noise into the covariance of speed and seatbelt use, then the residual variance in speed would also be affected. Therefore, for the benefit estimate, we selected the statistically significant odds ratio (1.033) based on the unadjusted belt use rate instead of using the adjusted model.. .

C.a.ii Combination trucks, person-based multivariable model with the mean travel speeds with unadjusted belt use rate:

Similar to the vehicle-based model with the mean travel speeds, we conducted a person-based multivariable logistic regression with the mean truck travel crash speeds without any belt use rate adjustment. The results of the modeling show that the risk of fatality would increase by 1.15 when the speed of a combination truck increases by each mile per hour (mph). The 1.15 odds ratio is statistically significant with p-value <5% (p-value=0.03).

Table 32
Combination trucks, person-based multivariable model with 5 means of travel speed, Maximum Likelihood Estimates, for each mile interval

Analysis of Maximum Likelihood Estimates					
Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	-13.6388	4.3084	10.0212	0.0015
Higher travel speed (1)	1	0.1395	0.0641	4.7396	0.0295
Non-belted /belted	1	0.8222	0.0617	177.4397	<.0001
AGE	1	-0.00271	0.000409	43.8381	<.0001
Female /male	1	0.4737	0.0779	37.0168	<.0001
Front seating	1	-0.0787	0.2093	0.1412	0.7070
Lane numbers >2	1	-0.1206	0.3511	0.1181	0.7312
Wet/icy Road Surf. vs. Dry	1	0.5848	0.2186	7.1573	0.0075

Table 33
Combination trucks, person-based multivariable model with 5 mean travel speeds, Odds Ratio Estimates, for each mile interval

	Odds Ratio Estimates		
	Point Estimate	95% Wald Confidence Limits	
Higher travel speed (1)	1.150*	1.014	1.304
Non-belted /belted	2.275	2.016	2.568
AGE	0.997	0.996	0.998
Female /male	1.606	1.379	1.871
Front seating	0.924	0.613	1.393
Lane numbers >2	0.886	0.445	1.764
Wet/icy Road Surf. vs. Dry	1.795	1.169	2.755

C.b.i SUTs, multivariable person-based model with a travel speed distribution, adjusted belt use:

We conducted a person-based multivariable logistic regression with the SUT speed distribution. The results of the modeling show that the risk of fatality would increase by 1.035 when the speed of a SUT is increased by one mile per hour (mph). The 1.035 odds ratio is statistically insignificant.

Table 34
SUTs, person-based multivariable model with travel speed distribution, Maximum Likelihood Estimates, for each mile interval

Analysis of Maximum Likelihood Estimates					
Parameter	**DF**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Intercept	1	-7.1023	1.8528	14.6939	0.0001
Higher travel speed (1)	1	0.0344	0.0216	2.5432	0.1108
Non-belted /belted	1	0.9168	0.1113	67.8145	<.0001
AGE	1	-0.00154	0.000580	7.0330	0.0080
Female /male	1	-0.0955	0.1806	0.2794	0.5971
Front seating	1	0.2731	0.2952	0.8562	0.3548
Lane numbers >2	1	-0.8657	0.2808	9.5047	0.0020

Analysis of Maximum Likelihood Estimates					
Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Wet/icy Road Surf. vs. Dry	1	-0.4658	0.2547	3.3441	0.0674

Table 35
SUTs, person-based multivariable model with travel speed distribution, Odds Ratio Estimates, for each mile interval

Odds Ratio Estimates			
Effect	Point Estimate	95% Wald Confidence Limits	
Higher travel speed (1)	1.035	0.992	1.080
Non-belted /belted	2.501	2.011	3.111
AGE	0.998	0.997	1.000
Female /male	0.909	0.638	1.295
Front seating	1.314	0.737	2.344
Lane numbers >2	0.421	0.243	0.730
Wet/icy Road Surf. vs. Dry	0.628	0.381	1.034

C.b.ii. SUT person-based multivariable with mean travel speed:

In the analysis above, if only five mean values, 62.07, 63.46, 66.63, 68.90, and 68.34 mph, from the original five normal distributions are used to represent the travel speeds of five speed limit zones of 55, 60, 65, 70 and 75 MPH, respectively, the travel speed range is much narrower (between 62.07 and 68.90 mph) when compared to using the travel speed distribution, and the odds ratios of speeds may be larger.

Table 36
SUTs, person-based multivariable model with 5 means of travel speeds, Maximum Likelihood Estimates, for each mile interval

Analysis of Maximum Likelihood Estimates					
Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq

Analysis of Maximum Likelihood Estimates					
Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	1	-10.9382	4.9568	4.8696
Higher travel speed (1)	1	1	0.0926	0.0723	1.6396
Non-belted /belted	1	1	0.8853	0.1162	58.0431
AGE	1	1	-0.00165	0.000565	8.5894
Female /male	1	1	-0.0608	0.1768	0.1181
Front seating	1	1	0.2598	0.2462	1.1136
Lane numbers >2	1	1	-0.7545	0.2852	7.0015
Wet/icy Road Surf. vs. Dry	1	1	-0.5316	0.2734	3.7805

Table 37
SUTs, Odds ratio of person-based multivariable model with 5 means of travel speeds, for each mile interval

Odds Ratio Estimates			
Effect	Point Estimate	95% Wald Confidence Limits	
Higher travel speed (1)	1.097	0.952	1.264
Non-belted /belted	2.424	1.930	3.044
AGE	0.998	0.997	0.999
Female /male	0.941	0.665	1.331
Front seating	1.297	0.800	2.101
Lane numbers >2	0.470	0.269	0.822
Wet/icy Road Surf. vs. Dry	0.588	0.344	1.004

C.c.i Bus, person-based multivariable model with a travel speed distribution, adjusted belt use:

We conducted a person-based multivariable logistic regression with the bus travel speed distribution.

Table 38

Table 38
Bus person-based multivariable model with travel speed distribution, Odds Ratio Estimates, for each mile interval

Analysis of Maximum Likelihood Estimates					
Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	-5.9407	2.6496	5.0269	0.0250
Higher travel speed (1)	1	0.0239	0.0366	0.4259	0.5140
Non-belted /belted	1	1.3160	0.3018	19.0187	<.0001
AGE	1	-0.00275	0.00101	7.4576	0.0063
Female /male	1	-0.1251	0.1595	0.6152	0.4328
Front seating	1	0.5490	0.4240	1.6760	0.1955
Lane numbers >2	1	-1.6145	0.6946	5.4023	0.0201
Wet/icy Road Surf. vs. Dry	1	-1.6925	0.9050	3.4972	0.0615

Table 39
Odds Ratio Estimates

Odds Ratio Estimates			
Effect	Point Estimate	95% Wald Confidence Limits	
Higher travel speed (1)	1.024	0.953	1.100
Non-belted /belted	3.729	2.064	6.736
AGE	0.997	0.995	0.999
Female /male	0.882	0.646	1.206
Front seating	1.731	0.754	3.975
Lane numbers >2	0.199	0.051	0.776
Wet/icy Road Surf. vs. Dry	0.184	0.031	1.085

Table 40
Bus person-based multivariable model with travel speed Means, Odds Ratio Estimates, for each mile interval

Analysis of Maximum Likelihood Estimates, 5 means					
Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	-14.8321	7.4738	3.9384	0.0472

Analysis of Maximum Likelihood Estimates, 5 means					
Parameter	**DF**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Higher travel speed (1)	1	0.1529	0.1104	1.9165	0.1662
Non-belted /belted	1	1.3424	0.3157	18.0775	<.0001
AGE	1	-0.00218	0.000601	13.1567	0.0003
Female /male	1	-0.0480	0.1644	0.0851	0.7705
Front seating	1	0.5603	0.4317	1.6850	0.1943
Lane numbers >2	1	-1.1403	0.7391	2.3806	0.1228
Wet/icy Road Surf. vs. Dry	1	-1.3000	0.9323	1.9445	0.1632

Table 41
Odds Ratio Estimates

Odds Ratio Estimates, from 5 speed means			
Effect	**Point Estimate**	**95% Wald Confidence Limits**	
Higher travel speed (1)	1.165	0.938	1.447
Non-belted /belted	3.828	2.062	7.108
AGE	0.998	0.997	0.999
Female /male	0.953	0.691	1.316
Front seating	1.751	0.751	4.081
Lane numbers >2	0.320	0.075	1.361
Wet/icy Road Surf. vs. Dry	0.273	0.044	1.694

D. Safety Benefits

D.a. Overview of safety benefits methodology:

The difference between the fatal crash rate at travel speeds that are higher than the speed limiting device setting and the fatal crash rate at the proposed speed setting represent the effectiveness of the speed limiting device. For combination trucks, the analysis shows that the odds ratio with the vehicle-based model ranges from 1.047 to 1.154 with the multivariable speed distribution approach and the multivariable mean speed approach, respectively. If we select the lowest odds ratio of 1.047 for the combination truck safety benefit estimate, it would provide the most conservative estimate. The 1.047 odds ratio is statistically significant. Likewise, with the vehicle-based model, we selected the statistically significant lower odds ratio of 1.033 for combination trucks. In general, for the safety benefit estimate involving combination trucks, we selected the vehicle-based approach with the travel speed distribution as the upper bound (with an odds ratio of 1.047) and the person-based approach as the lower bound (with an odds ratio of 1.033, statistically significant). We note that the resulting estimates can be thought of as 'upper' and 'lower' bounds on the estimate of potential lives saved, but this interval does not have a probability that can be calculated.

Since the notice proposes a speed limiting device setting a particular speed, we assume that all vehicles currently traveling above the speed setting would be limited to the speed setting and that there would be a reduction in the associated fatal crash rate for those vehicles to the rate associated with the speed setting.

Summary of derived fatal crash rates as a function of travel speed:

For example, the effectiveness of a speed limiting device set at 65 mph for the different types of vehicles subject to this proposed rule at each current travel speed is shown below.

Table 42

Upper Range: Percent reduction in fatal crash rate if **combination truck** speeds are limited to 65 mph for vehicle-based with speed distribution

Travel speed	Normalized risk of fatal crash	%-reduction in fatal crash risk with the speed limiter above

65	1.000000	0.0000
66	1.047000	0.0449
67	1.096209	0.0878
68	1.147731	0.1287
69	1.201674	0.1678
70	1.258153	0.2052
71	1.317286	0.2409
72	1.379198	0.2749
73	1.444021	0.3075
74	1.511890	0.3386
75	1.582949	0.3683
76	1.657347	0.3966
77	1.735243	0.4237
78	1.816799	0.4496
79	1.902188	0.4743
80	1.991591	0.4979
81	2.085196	0.5204
82	2.183200	0.5420
83	2.285811	0.5625
84	2.393244	0.5822
85	2.505726	0.6009

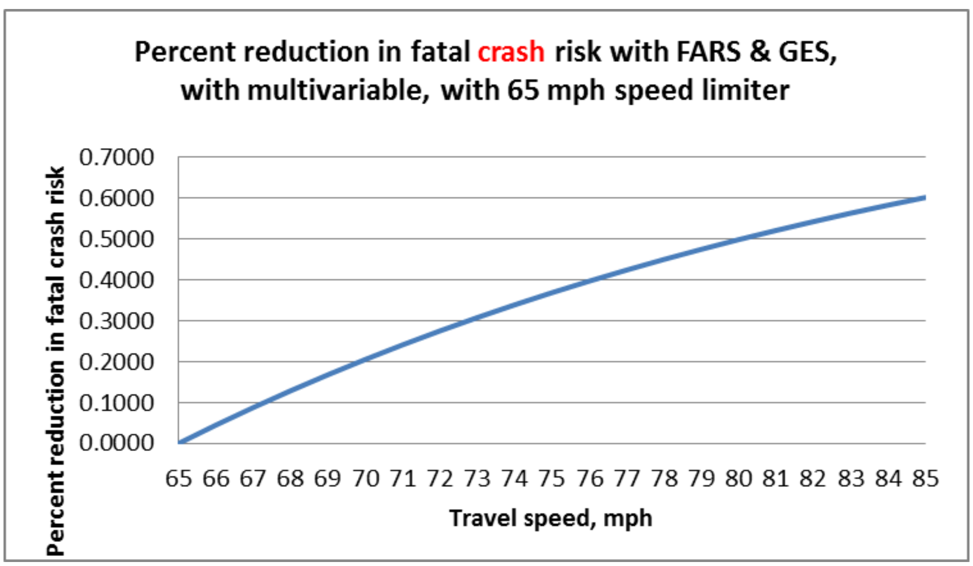

Figure 6 Combination truck, percent reduction in fatal crash risk for vehicle-based with speed distribution

Table 43

Lower Range: Combination truck, percent reduction in fatal crash risk for person-based with speed distribution

Travel speed	Normalized risk of fatal crash	%-reduction in fatal crash risk with the speed limiter above
65	1.000000	0.0000
66	1.033000	0.0319
67	1.067089	0.0629
68	1.102303	0.0928
69	1.138679	0.1218
70	1.176255	0.1498
71	1.215072	0.1770
72	1.255169	0.2033
73	1.296590	0.2287
74	1.339377	0.2534
75	1.383577	0.2772
76	1.429235	0.3003
77	1.476399	0.3227
78	1.525121	0.3443
79	1.575450	0.3653
80	1.627439	0.3855
81	1.681145	0.4052
82	1.736623	0.4242
83	1.793931	0.4426
84	1.853131	0.4604
85	1.914284	0.4776

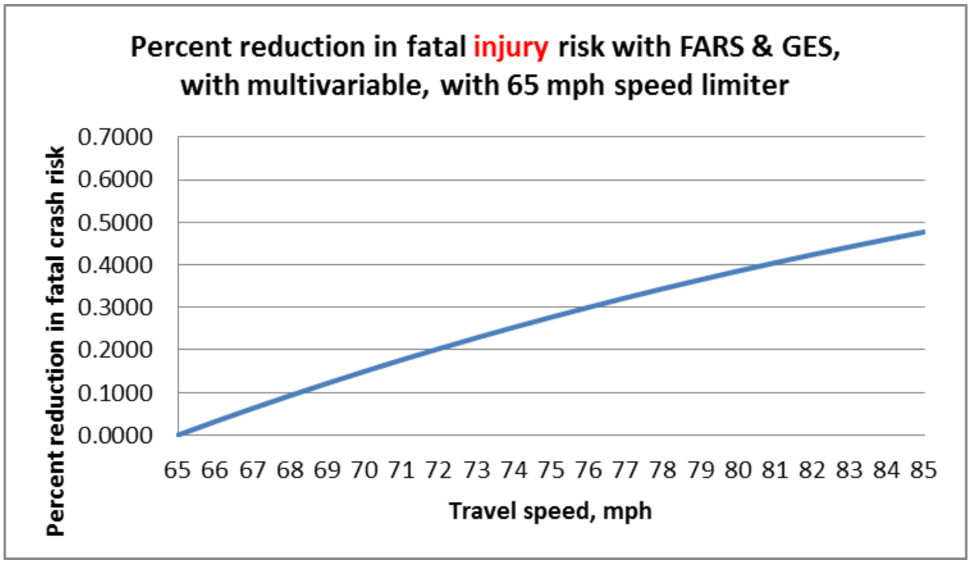

Figure 7 Combination truck, percent reduction in fatal crash risk for person-based with speed distribution

Table 44
Percent reduction in fatal crash rate if **single unit truck** speeds are limited to 65 mph, vehicle-based, the odds ratio is not statistically significant

Travel speed	Normalized risk of fatal crash	%-reduction in fatal crash risk with the speed limiter
65	1.00000	0.0000
66	1.01400	0.0138
67	1.02820	0.0274
68	1.04259	0.0409
69	1.05719	0.0541
70	1.07199	0.0672
71	1.08700	0.0800
72	1.10221	0.0927
73	1.11764	0.1053
74	1.13329	0.1176
75	1.14916	0.1298
76	1.16525	0.1418
77	1.18156	0.1537
78	1.19810	0.1653
79	1.21487	0.1769
80	1.23188	0.1882
81	1.24913	0.1994
82	1.26662	0.2105
83	1.28435	0.2214
84	1.30233	0.2321
85	1.32056	0.2427

Table 45
Percent reduction in fatal crash rate if **single unit truck** speeds are limited to 65 mph, person-based, the odds ratio is not statistically significant

Travel speed	Normalized risk of fatal crash	%-reduction in fatal crash risk with the speed limiter
65	1.00000	0.0000
66	1.03400	0.0329
67	1.06916	0.0647
68	1.10551	0.0954
69	1.14309	0.1252

70	1.18196	0.1539
71	1.22215	0.1818
72	1.26370	0.2087
73	1.30667	0.2347
74	1.35109	0.2599
75	1.39703	0.2842
76	1.44453	0.3077
77	1.49364	0.3305
78	1.54443	0.3525
79	1.59694	0.3738
80	1.65123	0.3944
81	1.70737	0.4143
82	1.76542	0.4336
83	1.82545	0.4522
84	1.88751	0.4702
85	1.95169	0.4876

Table 46
Percent reduction in fatal crash rate if **bus** speeds are limited to 65 mph, vehicle-based, the odds ratio is not statistically significant

Travel speed	Normalized risk of fatal crash	%-reduction in fatal crash risk with the speed limiter
65	1.00000	0.0000
66	1.49000	0.3289
67	2.22010	0.5496
68	3.30795	0.6977
69	4.92884	0.7971
70	7.34398	0.8638
71	10.94253	0.9086
72	16.30436	0.9387
73	24.29350	0.9588
74	36.19732	0.9724
75	53.93401	0.9815
76	80.36167	0.9876
77	119.73889	0.9916
78	178.41094	0.9944
79	265.83231	0.9962
80	396.09014	0.9975
81	590.17430	0.9983

82	879.35971	0.9989
83	1310.24597	0.9992
84	1952.26649	0.9995
85	2908.87707	0.9997

Table 47
Percent reduction in fatal crash rate if **bus** speeds are limited to 65 mph, person-based, the odds ratio is not statistically significant

Travel speed	Normalized risk of fatal crash	%-reduction in fatal crash risk with the speed limiter
65	1.00000	0.0000
66	1.29900	0.2302
67	1.68740	0.4074
68	2.19193	0.5438
69	2.84732	0.6488
70	3.69867	0.7296
71	4.80457	0.7919
72	6.24114	0.8398
73	8.10724	0.8767
74	10.53131	0.9050
75	13.68017	0.9269
76	17.77054	0.9437
77	23.08393	0.9567
78	29.98603	0.9667
79	38.95185	0.9743
80	50.59846	0.9802
81	65.72739	0.9848
82	85.37989	0.9883
83	110.90847	0.9910
84	144.07010	0.9931
85	187.14707	0.9947

<u>D.a.i. Combination Trucks:</u>

For the vehicle-based approach, we distributed the 9,285 combination trucks in fatal crashes from 2004 to 2013 (with 9,747 fatalities in 10 years) on roads with posted speed limits between 55 mph and 75 mph as follows:[45] For the distribution, we assumed that the number of fatalities at a given speed is proportional to VMT at that speed, where VMT is used a proxy for the exposure.

Table 48
Combination Truck Baseline Fatal Crash Distribution for 10 years

Posted speed:	55 MPH	60 MPH	65 MPH	70 MPH	75 MPH	Total, fatal crashes
Fatal Crash:	2,933	719	2,935	2,071	627	9,285
Travel speed						
45	0.002659	1.1057E-06	2.13714E-05	3.78019E-06	7.038E-05	0.0028
46	0.010102	7.5756E-06	9.47697E-05	1.62735E-05	0.0002198	0.0104
47	0.035412	4.6628E-05	0.000391653	6.58191E-05	0.0006532	0.0366
48	0.114531	0.00025783	0.001508443	0.000250109	0.0018466	0.1184
49	0.341739	0.00128085	0.005414407	0.000892915	0.0049665	0.3543
50	0.940746	0.00571644	0.018112054	0.002994996	0.0127079	0.9803
51	2.38922	0.02292019	0.056465003	0.009438162	0.0309348	2.5090
52	5.598164	0.08256132	0.164053637	0.027943669	0.0716419	5.9444
53	12.10155	0.26717833	0.444208868	0.077729217	0.1578461	13.0485
54	24.13469	0.77676926	1.120942768	0.203137466	0.330863	26.5664
55	44.40666	2.02884556	2.636176645	0.498770358	0.6597963	50.2303
56	75.38071	4.76071424	5.777772401	1.150578103	1.2517539	88.3215
57	118.0533	10.0360174	11.80160855	2.493655408	2.2593073	144.6438
58	170.5695	19.007144	22.46553853	5.077636879	3.879529	220.9993
59	227.3685	32.3398866	39.85541315	9.713856994	6.3376761	315.6154
60	279.6179	49.4340605	65.89502855	17.45929234	9.8498225	422.2561

[45] When we distributed the vehicles in fatal crashes with the Normal distribution, which is based on the overall observed average travel speeds, we assumed that the risk of fatal crashes would be the same regardless of travel speed. As a result, the number of vehicles in fatal crashes at a given travel speed is proportional to the exposure (e.g., the number of combination trucks traveling at a given speed). However, the crash data indicates that, in general, the risk of fatal crashes would increase as travel speed increases. Therefore, we expect that a greater number of fatalities would occur as travel speed increases, when compared to the fatalities distributed with the Normal distribution. Hence, we suspect that the approach would slightly underestimate the safety benefits since the method uses slightly lower percent reduction rates at higher travel speeds.

61	317.2527	67.8860039	101.534314	29.48264438	14.56378	530.7194
62	332.0865	83.7529998	145.8034768	46.77470924	20.48647	628.9042
63	320.7029	92.8296396	195.1271832	69.72052114	27.416214	705.7964
64	285.7328	92.4355702	243.3674677	97.63713298	34.905606	754.0786
65	234.8675	82.6909062	282.8799227	128.4618812	42.279536	771.1797
66	178.1113	66.4572774	306.4337383	158.7955772	48.720593	758.5185
67	124.6136	47.9836748	309.361231	184.4197345	53.41242	719.7907
68	80.43505	31.1250912	291.0650422	201.2246814	55.70822	659.5581
69	47.89948	18.1381892	255.2166847	206.2813523	55.276895	582.8126
70	26.31612	9.49605863	208.5561162	198.6751532	52.181352	495.2248
71	13.33885	4.4664144	158.8296766	179.7761225	46.863459	403.2745
72	6.237648	1.88729943	112.7288888	152.8358818	40.040611	313.7303
73	2.691094	0.71645476	74.564765	122.0740943	32.547256	232.5937
74	1.071131	0.24434469	45.96496506	91.60655681	25.169547	164.0565
75	0.393334	0.07486575	26.40675697	64.58541795	18.51756	109.9779
76	0.133256	0.02060771	14.1383281	42.78063776	12.961027	70.0339
77	0.04165	0.00509615	7.054656893	26.62348479	8.630629	42.3555
78	0.01201	0.00113219	3.280564571	15.56637224	5.4675504	24.3276
79	0.003195	0.00022598	1.421726759	8.550958298	3.295266	13.2714
80	0.000784	4.0521E-05	0.574220295	4.413133149	1.8894504	6.8776
Total	2,933	719	2,935	2,067	625*	9,279

* We note that the total number (625) from the distribution is slightly lower than the initial number (627) since we cut off the speed at 80 mph

For 65 mph speed limiting devices, we applied the percent reduction in the fatal crash rate if combination trucks are limited to 65 mph to derive the safety benefits for combination trucks on roads with a posted speed limit of 55 mph, 60 mph, 65 mph, 70 mph and 75 mph. Specifically, the effectiveness table that we generated using our regression model described earlier was applied to the distribution of travel speeds over the posted speed roads.[46], [47]

[46] Based on the regression model, for example, we generated the effectiveness table that shows the percent reduction in fatal crash risk when travel speeds are decreased to 65 mph with a 65 mph speed limiter. The effectiveness was applied to any travel speeds higher than 65 mph regardless of posted speed limits. (For example, the effectiveness was applied to trucks traveling at speeds higher than 65 mph on 60 mph posted roads.)

Table 49
Lives saved with Crash-based model with travel speed distribution, with 65 mph speed limiter

	55 MPH			60 MPH			65 MPH		
	2,878			709			2,869		
Speed	No. fatal	Effectiveness	Benefit	No. fatal	Effectiveness	Benefit	No. fatal	Effectiveness	Benefit
65	234.87	0.000	0.000	82.691	0.000	0.000	282.88	0.000	0.000
66	178.11	0.045	7.995	66.457	0.045	2.983	306.43	0.045	13.76
67	124.61	0.088	10.94	47.984	0.088	4.211	309.36	0.088	27.15
68	80.435	0.129	10.35	31.125	0.129	4.006	291.07	0.129	37.47
69	47.899	0.168	8.039	18.138	0.168	3.044	255.21	0.168	42.83
70	26.316	0.205	5.400	9.496	0.205	1.948	208.56	0.205	42.79
71	13.339	0.241	3.213	4.466	0.241	1.076	158.83	0.241	38.26
72	6.238	0.275	1.715	1.887	0.275	0.519	112.73	0.275	30.99
73	2.691	0.307	0.827	0.716	0.307	0.220	74.565	0.307	22.93
74	1.071	0.339	0.363	0.244	0.339	0.083	45.965	0.339	15.56
75	0.393	0.368	0.145	0.075	0.368	0.028	26.407	0.368	9.725
76	0.133	0.397	0.053	0.021	0.397	0.008	14.138	0.397	5.608
77	0.042	0.424	0.018	0.005	0.424	0.002	7.055	0.424	2.989
78	0.012	0.450	0.005	0.001	0.450	0.001	3.281	0.450	1.475
79	0.003	0.474	0.002	0.000	0.474	0.000	1.422	0.474	0.674
80	0.001	0.498	0.000	0.000	0.498	0.000	0.574	0.498	0.286
Total	2933		49	719		18	2935		292

(Continued)

70 MPH			75 MPH			
2,033			613			
No. fatal	Effectiveness	Benefit	No. fatal	Effectiveness	Benefit	Total lives saved
128.462	0.000	0.000	42.280	0.000	0.000	0.000
158.796	0.045	7.128	48.721	0.045	2.187	34.050
184.420	0.088	16.186	53.412	0.088	4.688	63.173
201.225	0.129	25.901	55.708	0.129	7.171	84.895
206.281	0.168	34.620	55.277	0.168	9.277	97.812
198.675	0.205	40.765	52.181	0.205	10.707	101.612
179.776	0.241	43.301	46.863	0.241	11.288	97.134

[47] We are not basing on benefits estimate on the posted speed. Rather, we are basing our benefits estimate on the observed travel speed of all trucks. This data is broken down by posted speed so that we can take the observations of truck speeds on certain roads in four states and extrapolate nationally.

152.836	0.275	42.021	40.041	0.275	11.009	86.257
122.074	0.307	37.536	32.547	0.307	10.008	71.520
91.607	0.339	31.016	25.170	0.339	8.522	55.546
64.585	0.368	23.785	18.518	0.368	6.819	40.501
42.781	0.397	16.968	12.961	0.397	5.141	27.777
26.623	0.424	11.281	8.631	0.424	3.657	17.947
15.566	0.450	6.998	5.468	0.450	2.458	10.937
8.551	0.474	4.056	3.295	0.474	1.563	6.294
4.413	0.498	2.197	1.889	0.498	0.941	3.424
2067.002		343.7586	625.18308		95.43411	799
Number of fatal crashes prevented per year						80
Number of lives saved per year, (No. fatalities/No. of fatal crashes)*fatal crashes prevented						84

For 65 mph speed limiters, the results show that the vehicle-based multivariable model with the combination travel speed distribution would save 84 lives annually by making it so that 80 crashes involving combination trucks would no longer be fatal. Similar to the approach used for the vehicle-based multivariable model, we estimated that a 65 mph speed limiter would save 62 lives with the person-based model with 65 mph speed limiters.

D.a.ii. Single Unit Trucks

For the safety benefit estimate for single unit trucks, we distributed the 417 single unit trucks (with a GVWR of 26,000 lbs and greater) in fatal crashes from 2004 to 2013 by estimated travel speed on roads (posted speed limits of 55 mph to 75 mph).

We then applied the percent reduction in the fatal crash rate if single unit trucks are limited to 65 mph to derive the safety benefits of 65 mph speed limiting devices.

Table 50
Number of single unit truck crashes that would be nonfatal instead of fatal with a 65 mph speed limiting device, vehicle-based model

	55 MPH			60 MPH			65 MPH		
	394			105			333		
Fatal Crash	No. fatal	Effectiveness	Benefit	No. fatal	Effectiveness	Benefit	No. fatal	Effectiveness	Benefit

65	17.391	0.0000	0	4.5606	0.0000	0	10.177	0.0000	0
66	13.188	0.0138	0.1821	3.6653	0.0138	0.0506	11.025	0.0138	0.152
67	9.2269	0.0274	0.2530	2.6464	0.0274	0.0726	11.130	0.0274	0.305
68	5.9558	0.0409	0.2433	1.7166	0.0409	0.0701	10.472	0.0409	0.428
69	3.5467	0.0541	0.1919	1.0004	0.0541	0.0541	9.1820	0.0541	0.4967
70	1.9486	0.0672	0.1309	0.5237	0.0672	0.0352	7.5033	0.0672	0.5039
71	0.9877	0.0800	0.0791	0.2463	0.0800	0.0197	5.7143	0.0800	0.4573
72	0.4618	0.0927	0.0428	0.1041	0.0927	0.0097	4.0557	0.0927	0.3761
73	0.1993	0.1053	0.0210	0.0395	0.1053	0.0042	2.6826	0.1053	0.2824
74	0.0793	0.1176	0.0093	0.0135	0.1176	0.0016	1.6537	0.1176	0.1945
75	0.0291	0.1298	0.0038	0.0041	0.1298	0.0005	0.9500	0.1298	0.1233
76	0.0099	0.1418	0.0014	0.0011	0.1418	0.0002	0.5087	0.1418	0.0721
77	0.0031	0.1537	0.0005	0.0003	0.1537	4.32E-05	0.2538	0.1537	0.039
78	0.0009	0.1653	0.0001	6.24E-05	0.1653	1.03E-05	0.1180	0.1653	0.0195
79	0.0003	0.1769	4.18E-05	1.25E-05	0.1769	2.2E-06	0.0512	0.1769	0.0090
80	5.81E-05	0.1882	1.09E-05	2.23E-06	0.1882	4.21E-07	0.0207	0.1882	0.0039
Total	217.172		1.15915	39.654		0.318454	105.577		3.4630

(continued)

70 MPH			75 MPH			
160			26			
No. fatal	Effectiveness	Benefit	No. fatal	Effectiveness	Benefit	Total lives saved
2.917559	0.0000	0	0.497285	0.0000	0	0.0000
3.606482	0.0138	0.049794	0.573044	0.0138	0.007912	0.4426
4.188444	0.0274	0.114859	0.628229	0.0274	0.017228	0.7629
4.57011	0.0409	0.186693	0.655232	0.0409	0.026767	0.9547
4.684954	0.0541	0.253426	0.650158	0.0541	0.035169	1.0312
4.512206	0.0672	0.30301	0.613749	0.0672	0.041215	1.0141
4.082981	0.0800	0.326773	0.551201	0.0800	0.044114	0.9270
3.471129	0.0927	0.321894	0.470952	0.0927	0.043674	0.7942
2.772483	0.1053	0.291834	0.382816	0.1053	0.040296	0.6396
2.08052	0.1176	0.244699	0.29604	0.1176	0.034819	0.4849
1.46683	0.1298	0.190391	0.217801	0.1298	0.02827	0.3463
0.971611	0.1418	0.137786	0.152446	0.1418	0.021619	0.2331
0.604659	0.1537	0.092912	0.101512	0.1537	0.015598	0.1480
0.353535	0.1653	0.058456	0.064308	0.1653	0.010633	0.0888
0.194205	0.1769	0.034349	0.038758	0.1769	0.006855	0.0503
0.100229	0.1882	0.018866	0.022223	0.1882	0.004183	0.0269
Number of fatal crashes prevented for 10 years						8
Number of fatal crashes prevented per year						1
Number of lives saved per year						1

When the percent reduction is applied to the SUT target population, the results show that, for example, a 65 mph speed limiting device would save one (1) life with the vehicle-based model. Similar to the approach used for the vehicle-based model, we estimated that a 65 mph speed limiter would save 2 lives with the person-based model, annually, on roads with posted speed limits of 55 mph to 75 mph.

D.a.iii. Buses:

The agencies do not have the same type of observational travel speed data for large buses that we used for the heavy truck analyses. However, we have tentatively concluded that the travel speed of buses would likely be more similar to the travel speed of trucks than the travel speed of automobiles and, accordingly, used observed truck travel speed data as a proxy for large bus travel speed.

For buses, the fatality target population (based on 2004 - 2013 FARS data) showed that there were 234 fatal bus crashes on 55 – 75 mph roads (for buses with a GVWR of 26,000 lbs and greater). Similar to the approach used for combination trucks and single unit trucks, we used the overall risk of a fatal crash in the calculation. For the safety benefit estimate for buses with the vehicle-based approach, we distributed the 234 fatal bus crashes by estimated travel speed on roads with posted speed limits of 55 mph to 75 mph.

We then applied the percent reduction in the fatal crash rate if buses are limited to 65 mph to derive the safety benefits of 65 mph speed limiting devices for buses on roads.

Similar to the approach used for the combination trucks and SUTs, when the percent reduction rate is applied to the bus target population, the results show that 65 mph speed limiting devices would prevent four fatalities based on the vehicle-based model and three fatalities based on the person-based model, annually, on roads with posted speed limits of 55 mph to 75 mph. However, we note that the statistically insignificant odds ratios (0.9960 and 1.024) are statistically insignificant for buses. As a result, we do not have a high degree of confidence the estimated number of lives saved (about one life) can be realized with a 65 mph speed limiter.

E. Total lives saved

In summary, the single unit truck and bus crash analysis showed that a 65 mph speed limiting device would result in a relatively small amount of benefits. We estimated that a 65 mph speed limiting device would save 1 – 2 lives annually for single unit trucks and about one life annually for buses on roads with a posted speed limit of 55 mph to 75 mph.

Overall, based on the most conservative analysis, for example, a 65 mph speed limiter would save 62 – 84 lives involving combination trucks, 1 – 2 involving SUTs and about one life involving buses. We note that additional analyses have indicated potentially higher safety benefits. For example, the safety benefits for combination trucks with 65 mph speed limiters as summarized in Appendix A indicate that the full range for combination trucks is 62-204 fatalities prevented if 65 mph speed limiters are used. When all applicable vehicles are considered, it resulted in a range of 63 to 214 lives saved with 65 mph speed limiters.

Table 51
Summary of Overall Odds Ratio Considered, with 65 mph speed limiters

Vehicle	Approach, Vehicle or Person based	Speed distribution, multivariable	
		Odds	Lives saved
CT	Vehicle	1.047	84
	Vehicle	1.154	204
	Person	1.033	62
	Person	1.150	201
SUT	Vehicle	1.014	1
	Vehicle	1.079	4
	Person	1.035	2

	Person	1.097	5
Bus	Vehicle	0.996	Less than 1
	Vehicle	1.081	3
	Person	1.024	1
	Person	1.165	5
Total			63 - 214

F. Non-fatal injuries and property damage prevented:

The benefit estimate methodology assumes that the number of crashes would be the same but the impact speed decreases with a speed limiter. When the impact speed is reduced by a speed limiting device, the reduction in crash severity would result in a lower injury severity and also reduced property damage. The model used above to calculate safety benefits only estimates the reduction in fatalities. It does not directly provide injury benefits.

For combination trucks, single unit trucks, and buses, estimates of the number of property damage only (PDO) vehicle involvements and injuries prevented were estimated based on ratios between lives saved and injuries prevented in a 2009 NHTSA rulemaking amending FMVSS No. 121, Air Brake Systems, using 2004-2006 GES and FARS data.[48] Specifically, in that rulemaking, NHTSA developed a relationship between vehicle impact speed and injury probability. Based on the physics of the crash type addressed in that rule, NHTSA estimated a reduction in impact speed and thus a decrease in delta-V. Using these two pieces of data, the air brake rule estimated the net reduction of fatalities and injuries at each MAIS level.

[48] Preliminary Regulatory Impact Analysis, FMVSS No. 121 Air Brake Systems Amending Stopping Distance, Dec 13, 2005 (Docket No. NHTSA-2005-23306-0001).

The agencies applied these ratios for the current rulemaking because we believe that they are based on the types of crashes (and injuries) that are most likely to be affected by the proposed speed-limiting requirements. Combination truck crashes make up the vast majority of the target population, and the agencies believe that those crashes in which a heavy vehicle hits another vehicle from behind are the most common type of crash that would be affected by the proposed rule.

In the air brake rule, in order to estimate the impact of improved stopping distance on vehicle safety, NASS-CDS data[49] (originally analyzed for the agency's Tire Pressure Monitoring System FMVSS No. 138 Regulatory Analysis and Evaluation, March 2002) were examined to derive a relationship between vehicle impact speed and the probability of injury. The CDS data used for these two rules was developed through crash investigation, which allows the agency to directly correlate the relationship between delta-V (estimated through crash scene investigation) and the probability of each level of MAIS injury. For instance, the model predicts that for a crash in which a 30 mph delta-V is achieved, the probability of the crash causing a MAIS 1 injury is 40.6%, while the probability of the crash causing a MAIS 5 injury is 1.2%.

The air brake rule further investigated a target population (for that rule using 2004-2006 FARS and GES data) that included injury and fatal crashes. The total number of injured occupants was then distributed based on the injury risk profile.

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[49] 1995-1999 CDS data all passenger vehicle occupants involved in crashes where at least one passenger vehicle used brakes.

Once we had the injury distribution by delta-V and severity level involving combination trucks, we developed a theoretical truck impact speed profile with truck's brakes applied when crashes occur. In order to construct the impact speed profile, we considered the existing average combination truck brake performance, speeds when the brakes are initially applied, and the distance from the initial braking application. For example, the test data showed that on average a combination truck produces a deceleration of 3.966 m/sec^2. Similar to the original (i.e., baseline) truck speed distribution profile, we developed a truck speed profile with the same initial speeds but with enhanced brakes. For example, the test data showed that on average a truck produces a deceleration of 4.310 m/sec^2 with the enhanced brakes.

Up to this point, we have (a) an injury distribution by delta-V and injury severity involving combination trucks, (b) an injury risk profile by delta-V and injury severity involving combination trucks, (c) a speed profile with the existing brakes, and (d) a speed profile with the enhanced brakes. Based on the baseline truck speed distribution and the enhanced brake truck speed distribution, we developed a percent reduction in impact speed with the enhanced brakes for a given baseline impact speed.

In order to use the injury risk profile (i.e., profile table) discussed in above, the impact speeds were converted into delta-V's based on the conservation of momentum principle and the average mass of heavy trucks and light vehicles. As a result, we now have a new distribution of crashes in delta-V involving combination trucks. With the original injury distribution by delta-V's and the percent reduction (profile) in delta-V's with the enhanced brakes, we then developed an expected injury distribution with the enhanced brakes. For the total net benefit of the enhanced brakes, we compared the original injury profile and the projected injury profile to determine the net difference by injury severity level. The net benefit shows that the enhanced brakes, for example, would prevent about 18 (18.32) times higher number of MAIS 1 injuries when compared to the total number of lives saved, resulted in a ratio of 1.32 for MAIS 1 injuries prevented over lives saved. Likewise, we developed ratios for the other injury severity levels shown the table below.

Table 52
Net occupant injuries prevented with air brake system requirement in combination truck crashes, 2004-2006 GES and FARS

Distribution of injuries	No.	Ratio to fatal
MAIS 1	4,707	18.32
MAIS 2	615	2.39
MAIS 3	237	0.92
MAIS 4	32	0.12
MAIS 5	15	0.06
Fatalities	257	1.00

Based on the ratios above, for example, we estimated the number of injuries prevented by 65 mph speed limiting devices for the vehicles in the speed limiting devices target population. For example, the ratio between the number of MAIS 1 injuries and the number of fatalities is 18.32. The 18.32 ratio was applied to the 85 lives saved (based on the vehicle-based model) to estimate the 1,551 MAIS 1 injuries prevented. Likewise, for example, we expect that a 65 mph speed limiting device would save 1,179 - 1,551 MAIS 1, 154 - 203 MAIS 2, 59 - 78 MAIS 3, 8 - 11 MAIS 4, 4 - 5 MAIS 5, and 64 - 85 lives. With lower travel speeds, the severity of current injuries would decrease, including “no-injury.” For example, with lower travel speeds, some of MAIS 2 injuries would be downgraded to MAIS 1 and “no-injury.” Some fatalities prevented by this rule would also become injuries. The number of injuries prevented in the analysis represents the net injury benefits. In other words, the injury benefits are the difference between the current injuries and injuries that we expect with the speed limiters rule. This result, which shows a significant number of fatalities avoided, followed by lower numbers of serious injuries and then higher numbers of less severe injuries avoided makes intuitive sense: there are a lot more non-fatal injuries than fatal injuries when crashes occur. Simply the reduction in injury risk, whether fatal or non-fatal injuries, would decrease as the impact speed decreases with a speed limiter. We request for comments on the methodology used for non-fatal injuries.

We note that additional analyses have indicated potentially higher safety benefits. For example, the safety benefits for combination trucks from these analyses are summarized in Appendix A indicate that the full range for Combination Trucks is 62-204 fatalities prevented. Injuries are calculated as a direct function of fatalities, total injuries prevented could be higher than the range indicated in Table 53.

Table 53
65 mph speed limiting devices for combination trucks, SUT & buses

Injury level	Lower	Upper
MAIS 1	1,192	1,551
MAIS 2	156	203
MAIS 3	60	78
MAIS 4	8	11
MAIS 5	4	5
Fatality	65	85

The agencies recognize the differences between this rule and the air brake rule that could affect the ratio of injuries to fatalities. First, there are differences in target populations. The air brake rule only includes crashes with brakes applied. The target population for speed limiters includes both braked and unbraked crashes. The air brake rule target population includes all roads, whereas this speed limiters target population only include roads with a posted speed limit of 55 mph and higher. Second, the air brake rule attempts to measure both crash avoidance and crash mitigation benefits. However, this rule only measure crash mitigation benefits. Third, the air brake rule only applies to combination trucks whereas this analysis applies the same ratios to all heavy vehicles, including single unit trucks and buses. We are seeking comments on the relevance and effect of these differences and on any other aspect of this method of measuring injury reduction.

G. Summary of lives saved and injuries prevented:

For the speed limiting device benefit analysis, 2004 – 2013 General Estimate Sampling System (GES) and Fatality Analysis Reporting System (FARS) were used for combination trucks, single unit trucks, and buses. The analysis examined heavy vehicle (with a GVWR greater than 11,793 kg (26,000 lbs.) crash involvements by vehicle speed. Only cases where the speed of the heavy vehicle likely affected the severity of the crash were included.

The agency does not have adequate data regarding the crash speeds involved in a particular crash and therefore used two proxies for the actual speed: a mean speed based upon observed travel speeds on particular roads, and a distribution of the travel speed. When these travel speeds are used to estimate the safety benefits, for example, speed limiting devices set at 65 mph would save 62 - 204- lives, annually, in combination truck crashes. Likewise, speed limiting devices set at 65 mph would save 1 – 5 lives and less than one life to 5 lives in single unit truck and bus crashes, respectively.

The expected benefit will accrue over the lifetime of each model year vehicle. For the analysis, we estimate that a heavy vehicle could last as long as 35 years. As a vehicle ages, the proportion of the total benefit realized decreases since the survival probability and the exposure rate (i.e., VMT) decrease each year. Based on the aggregate exposure (product of survival probability and exposure rate) of any specific model year heavy vehicle, for example, 88% of the expected benefit would be realized within 15 years.

Table 54
Summary of lives saved with 65 mph speed limiting device for Heavy vehicles w/ a GVWR greater than 26,000 lbs.

Vehicle	Based on "vehicle-based" model	Based "person-based" model
Combination Trucks	84 - 204	62 - 201
Single Unit Trucks	1 - 4	2 – 5
Buses	Less than one - 4	1 – 5

Research by University of Michigan Transportation Research Institute:

As a way to test the reasonableness of the above estimate, we examined a study done by the University of Michigan Transportation Research Institute (UMTRI) on the fatal injury risk involving combination trucks in fatal front-to-rear end crashes. (The UMTRI report "Performance Characterization and Safety Effectiveness Estimates of Forward Collision Avoidance and Mitigation Systems for Medium/Heavy Commercial Vehicles," August 2012 is available in the docket NHTSA-2013-0067.)[50]

As background, the objective of the study was to estimate the safety benefits of Forward Collision Warning with Collision Mitigation Braking (CMB) technology as applied to heavy trucks, including single unit and tractor semitrailers. Benefits were estimated through the following steps: (1) first characterizing the actual performance of these systems in various pre-

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[50] http://www.regulations.gov/#!documentDetail;D=NHTSA-2013-0067-0001

crash scenarios under controlled test track conditions, and then reverse engineering the algorithms that control warnings and automatic braking actions; (2) developing a comprehensive set of simulated crash events representative of actual truck striking rear-end crashes. This virtual, "reference" crash database was developed by analyzing vehicle interactions (or conflicts) from naturalistic studies to create thousands of crashes in a computer simulation environment, and then weighting each simulated crash based on probabilities derived from GES and Trucks in Fatal Accidents (TIFA)[51] crash databases; (3) overlaying (or inserting) the CMB technology algorithms into the simulations of each crash event and observing the kinematic impacts (i.e., benefits) from having initiated warnings and/or automatic braking (including reduction in impact speed, or elimination of the crash).

In the study, UMTRI estimated the fatal injury risk in rear impacts for occupants in struck automobiles, as shown below.

Table 55
Coefficients and Fit Statistics for Injury Model in Rear Impacts

Analysis of Maximum Likelihood Estimates						
Parameter		**DF**	**Estimate**	**Standard**	**Wald**	**Pr > ChiSq**
Intercept	K	1	-10.8931	1.1968	82.8420	<.0001
Intercept	A	1	-6.3277	0.4452	201.9732	<.0001
Intercept	B	1	-5.5338	0.6788	66.4582	<.0001
Intercept	C	1	-4.3782	0.9796	19.9763	<.0001
Ln (dV mph)		1	1.4881	0.3727	15.9394	<.0001

[51] http://www.nhtsa.gov/Data/Fatality+Analysis+Reporting+System+(FARS)/Trucks+in+Fatal+Accidents+(TIFA)+and+Buses+in+Fatal+Accidents+(BIFA)

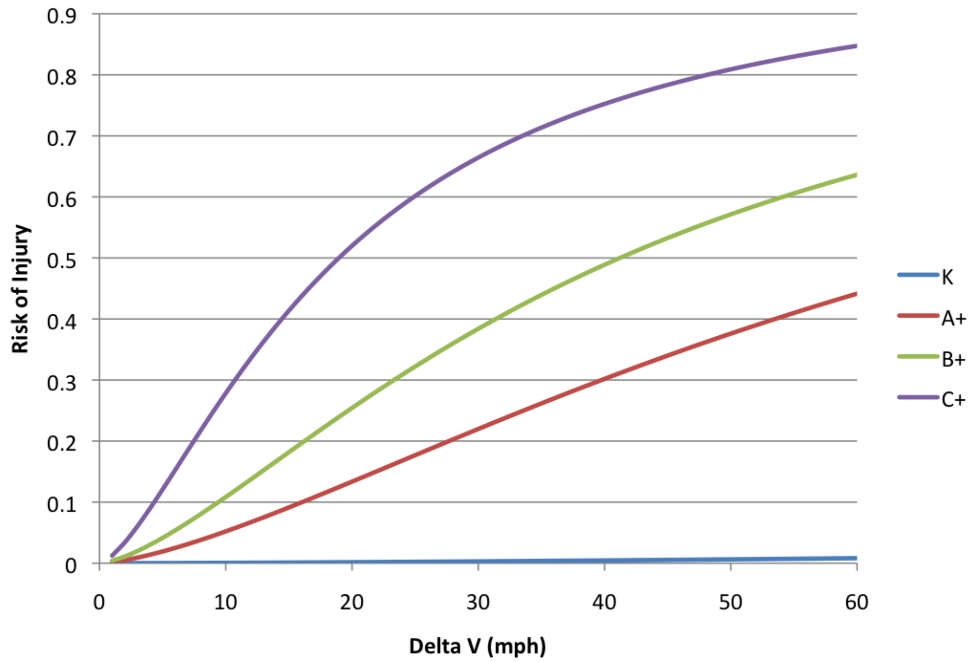

Figure 8. Graphical representation of risk functions for rear impacts

In order to compare the fatal injury risk developed by UMTRI with the fatal injury risk estimated in the PRIA, for illustration, we selected a set of input parameters, as shown below.

Parameters:	Input Parameters:	
Subject vehicle deceleration	0.30	g
Other vehicle deceleration	0.31	g
Subject vehicle initial travel speed	70	mph
Time "T" for the headway	2	sec

A = Subject vehicle deceleration - Other vehicle deceleration

B = -(2)*(Subject vehicle initial travel speed - Other vehicle initial travel speed)

C = (2)*(Subject vehicle initial travel speed - Other vehicle initial travel speed)*T

$$t = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$$

With the input parameters above, we solved a quadratic equation for a striking truck travel speed range of 65 mph to 89 mph and a struck vehicle travel speed range of 0 mph to 89 mph. For example, with a striking vehicle initial speed of 70 mph and a struck vehicle initial speed of 64 mph, we calculated that the striking vehicle speed at impact would be 25.61 m/sec (57 mph) and the struck vehicle speed at impact would be 22.74 m/sec (51 mph). With these two impact speeds, the relative speed was calculated to be 2.87 m/sec (6 mph).

As part of the FMVSS No. 121 (as discussed previously), we estimated that the delta-V involving combination trucks in rear end crash would be 87% of the relative speed.

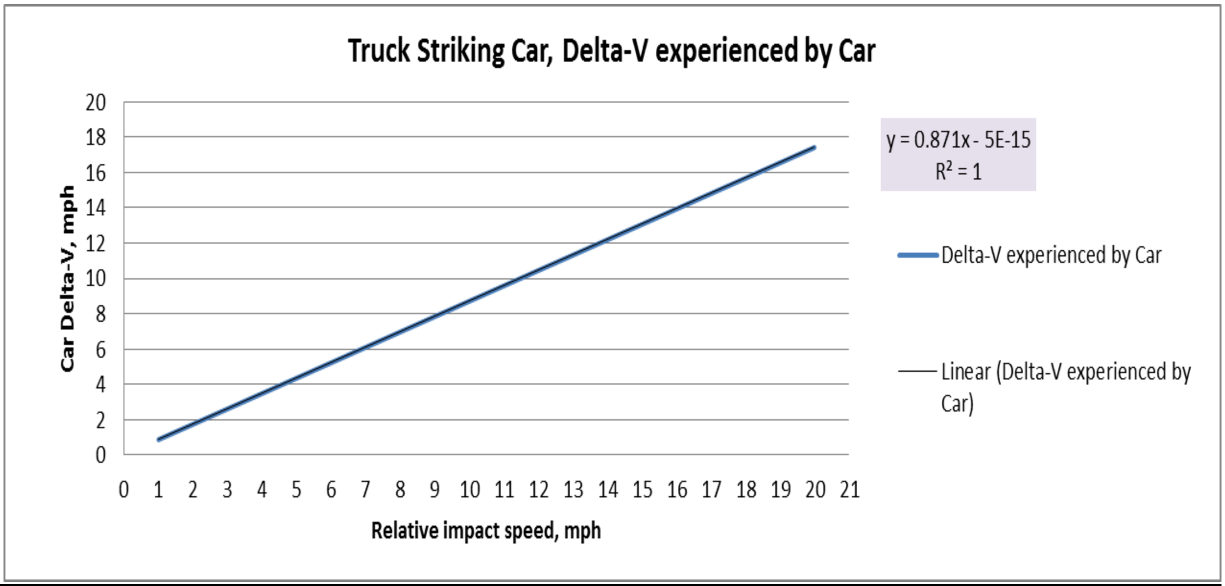

Figure 9. Delta-V experienced by the struck automobile when struck by a combination truck in front to rear end crashes.

With the 0.87 factor, the delta-V experienced by the struck vehicle was calculated to be 2.5 m/sec (5.60 mph) with the input parameters above and the 70 mph striking vehicle initial speed. With these conditions, according to the UMTRI fatal injury risk probability, the fatal injury risk would be 0.02% (0.00024). When the initial truck speed is reduced to 65 mph, the fatal injury risk would be 0.002% (0.00002).

Table 56
Fatal injury risk at a given delta-V with UMTRI injury risk probability

Delta-v (mph)	Ln Delta-v	K	A+	B+	C+

6	1.72189	0.00024	0.02264	0.04873	0.13993
1	0.17685	0.00002	0.00232	0.00511	0.01606

When the process above was applied to the striking truck travel speed range (65 mph - 89 mph) and the struck vehicle travel speed range (0 mph - 89 mph), it resulted in a percent reduction range with respect to truck travel speed, as shown below.

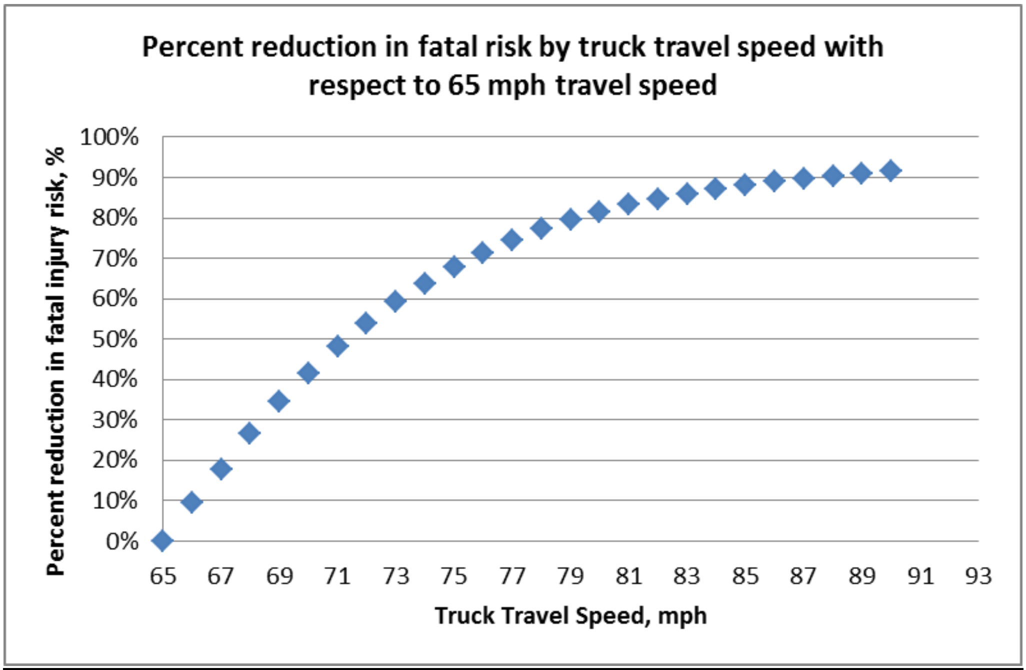

Figure 10 percent reduction in fatal injury risk with given input parameters

The result shows that the UMTRI based percent redcution in fatal injury probability is higher when compared to the precent reduction rate estimated in the PRIA.

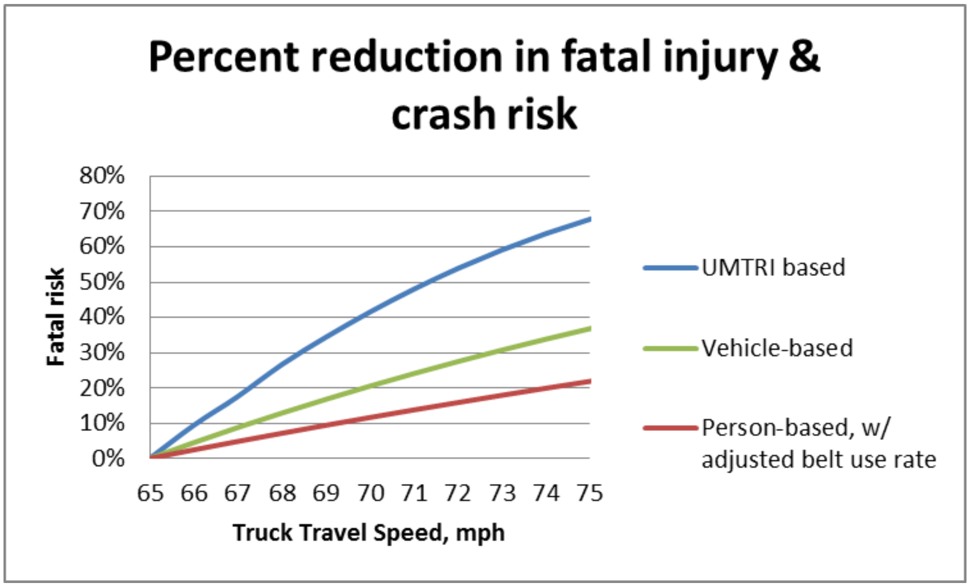

Figure 11. Fatal crash and injury risk based on UMTRI research

We note that the calculation above is based on a single set of input parameters and will not be used in the benefit estimate in the PRIA.

Estimated Property Damage Benefits:

Similar to the injury analysis, the agencies used in the 2009 NHTSA rulemaking to amend FMVSS No. 121 to determine the ratio between fatalities prevented and property-damage-only (PDO) crashes prevented. When the impact speed is reduced by a speed limiting device, the reduction in crash severity would result in a lower injury severity (as explained above) and also reduced property damage. The reductions in property damage were calculated by multiplying the estimated amount of property damage and travel delay costs per injury at various levels of severity, including PDO crashes, by the estimated number of injuries prevented, fatalities prevented and the number of vehicle involvements in PDO prevented, respectively.

The estimates of the property damage and travel delay costs per injury levels of severity and per fatality, and property damage costs per vehicle involved in PDO crashes were made based on the estimated property damage used in 2009 NHTSA rulemaking to amend FMVSS No. 121 and adjusted to 2013 dollars as shown below:

Table 57
Estimated "Property Damage" per PDO Vehicle Involvement, Injury or Fatality in 2013 dollars[52]

Property Damage per:	Property Damage
PDO Vehicle Involvement[53]	$15,488
MAIS 1 Injury	$15,901
MAIS 2 Injury	$16,483
MAIS 3 Injury	$16,244
MAIS 4 Injury	$16,588
MAIS 5 Injury	$16,568
Fatality	$43,087

Table 58
Illustration of number of injuries and PDO prevented with 65 mph speed limiting device

Severity	Lower	Upper
PDO	3,882	5,109
MAIS 1	1,179	1,551
MAIS 2	154	203
MAIS 3	59	78
MAIS 4	8	11
MAIS 5	4	5
Fatalities	64	85

[52] A 1991 Federal Highway Administration (FHWA) report, *The Cost of Highway Crashes*, included data which compared the property damage, travel delay and emergency service costs of crashes involving heavy vehicles and those involving other vehicle classes. However, the data in the FHWA report are not broken down per fatality, per injury at different levels of injury severity or per vehicle involved in PDO crashes.

[53] For the estimates of the "property damage" related to vehicles involved in PDO crashes, costs other than those directly resulting from damage to the vehicles and property and travel delay that resulted from the crash were included. These other costs included "workplace" costs, insurance administration costs, emergency service costs, and household productivity. The actual damage was about 90% of the total cost per vehicle involved in a PDO crash.

Table 59
Property benefits with 65 mph speed limiting device

Injury level	Property damage cost	Injury prevented or PDO		Property damage prevented ($M)	
		Lower	Upper	Lower	Upper
PDO	$15,488	3,882	5,109	$60.12	$79.13
MAIS 1	$15,901	1,179	1,551	$18.74	$24.67
MAIS 2	$16,483	154	203	$2.54	$3.34
MAIS 3	$16,244	59	78	$0.96	$1.27
MAIS 4	$16,588	8	11	$0.13	$0.17
MAIS 5	$16,568	4	5	$0.06	$0.08
Fatal	$43,087	64	85	$2.77	$3.65
Total				$85.34	$112.32

When the property savings are discounted at 7%, it shows that $54.8 - $75.8 million in property damage would be prevented with a 65 mph-speed limiting device.

Table 60
Property Damage Reduced (in millions, in 2013 dollars)

Setting of speed limiting device	Discount rate		
	Not discounted	Discounted at 3%	Discounted at 7%
65 mph limit	$85.34 - $112.32	$69.08 - $90.92	$54.85 - $72.19

As noted previously for injuries, additional analyses have indicated potentially higher safety benefits. For example, with 65 mph speed limiters, the safety benefits for combination trucks from these analyses are summarized in Appendix A indicate that the full range for combination trucks is 62-204 fatalities prevented, implying that total property damage savings could be greater than that noted above.

<u>Effects of Differential Speed Limits on Safety:</u>

With the maximum travel speed of heavy trucks limited by speed limiting devices, differential speed limits for passenger vehicles and heavy trucks would likely result on roads with speed limits above a particular speed setting. There is anecdotal evidence that trucks have significantly different operating characteristics than passenger vehicles and, as a result, trucks operate at lower speeds.[54] This conclusion is supported by the State data the agencies relied on the safety benefit analysis, which showed average passenger car speeds to be higher than truck speeds on roads with the posted speed limits of the speed setting and above. For example, the travel speed observed in Missouri (where the posted speed limit for both passenger cars and trucks is 70 mph) showed that passenger cars have an average travel speed of 72.6 mph whereas trucks have an average travel speed of 68.6 mph.

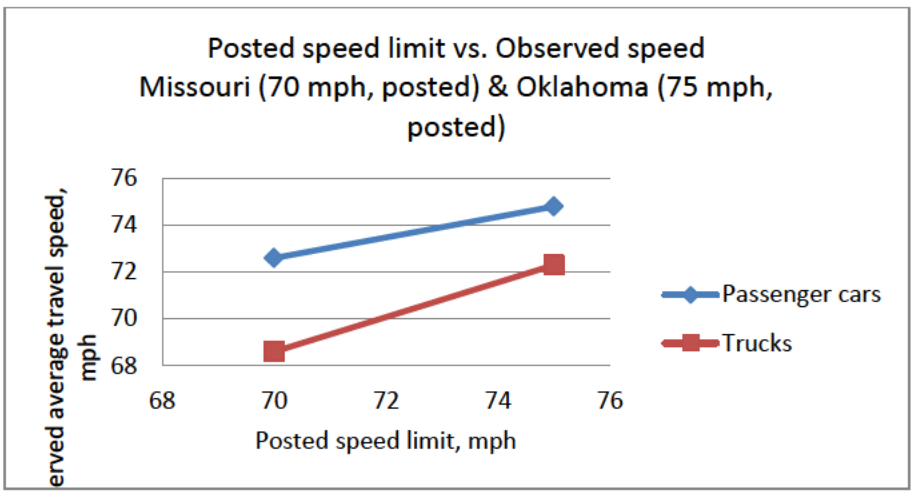

Figure 12. Observed average travel speed at given posted speed of 70 mph and 75 mph

[54] While one might expect crashes caused by heavy truck drivers going forward to be reduced, one might also expect that there might be an increase in crashes caused by speeding vehicles coming up behind heavy trucks, as they try to change lanes and go around the heavy trucks. We cannot quantify either of these conditions.
Thus, the impact of speed limiting devices on preventing crashes overall is unknown. We are estimating that speed limiting devices will reduce the severity of crashes when the heavy truck is the striking vehicle.

Table 61
Posted travel speeds vs. Observed average travel speed by state[55]

State	Hwy	Speed Limit		Sample Size		Average Speed (mph)		Std Dev.		85th % 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

There have been many studies conducted on the impact of differential speed limits. According to a report "The Safety Impacts of Differential Speed Limits on Rural Interstate Highways" prepared by the Virginia Transportation Research Council (VTRC) and disseminated under sponsorship of the U.S. Department of Transportation, no consistent safety effects of Differential

[55] As discussed previously, we do not have data on travel speeds for buses. However, we have no information to conclude that they are traveling at different speeds than heavy trucks on 55 mph+ roads.

Speed Limit (DSL) as opposed to Uniform Speed Limit (USL) were observed.[56] In the report, the authors examined several States that have either eliminated or implemented a lower speed limit for trucks. For the VTRC study, speed and crash data were collected from States that had been identified as having changed their speed limits at least once during the 1990s from USL to DSL or vice versa. In addition, the authors selected nine States so they could be divided into four policy groups based on the type of speed limit employed during the period.

Table 62
Types of Speed Limits throughout the 1990s on Rural Interstate Highways

Maintained USL	Maintained DSL	Changed from USL to DSL	Changed from DSL to USL
Arizona Iowa North Carolina	Illinois Indiana Washington	Arkansas Idaho	Virginia

In the VTRC study, five speed measures (mean speeds, speed variance, 85th percentile speeds, median speeds, and noncompliance rates) were analyzed for the five States (Iowa, Illinois, Indiana, Idaho and Virginia) where such speed monitoring data were readily available. Speed data were generated from speed monitoring stations throughout the States. We note that the authors were unable to obtain speeds by vehicle type (passenger cars and trucks).

Figure 13 illustrates the trends in mean speeds, for all vehicle types, among the five States with speed data. The main observation is that all speeds appear to be increasing over time, regardless of speed limit type.[57]

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[56] Publication Number: FHWA-HRT-04-156, Date: September 2004

[57] There were changes in speed limits over this timeframe. The data only shows that travel speeds have increased. However, it does not draw any conclusions about compliance with speed limits.

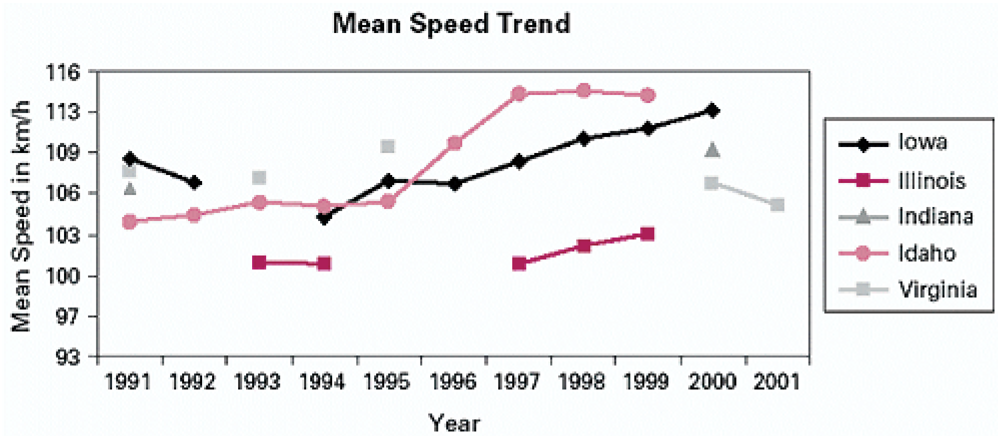

Figure 13. Mean Speed for All Vehicles

Figure 14 presents an overall representation of crash data from the various States. According to the study, only North Carolina showed an increase in the total crash rate; the other States showed no significant change in the total crash rate. Note that speed limits changed in Idaho (1996, 1998), Arkansas (1996) and Virginia (1994).

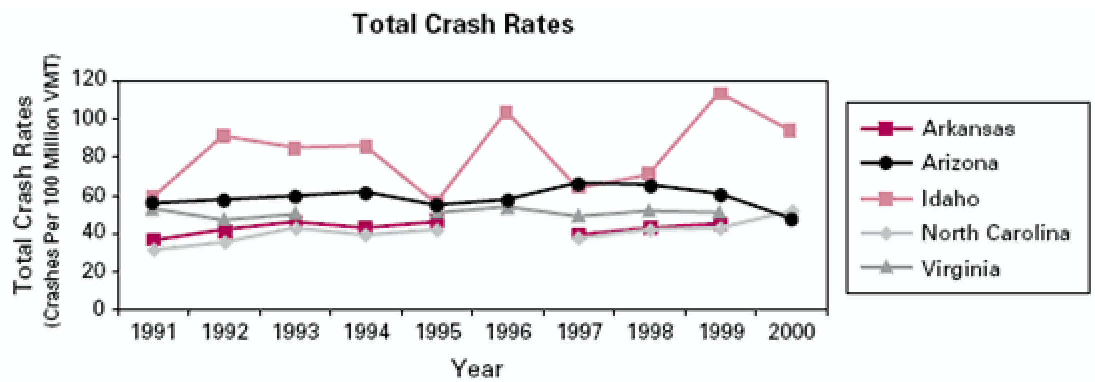

Figure 14. Total Crash Rates per million vehicle-miles traveled (VMT)

According to the report, Virginia switched from a differential speed limit of 105 km/h (65 mph) for cars and 88 km/h (55 mph) for trucks to a uniform speed limit of 105 km/h (65 mph) for all vehicles in 1994. Arkansas adopted a differential speed limit by raising the speed limit for cars to 113 km/h (70 mph) but maintaining 105 km/h (65 mph) for trucks in 1996. Idaho changed from a uniform speed limit of 121 km/h (75 mph) for all vehicles to a 105 km/h (65 mph) limit for trucks in 1998.

Table 63
Accident Proportions by Speed Limit, Collision Type, and Vehicle Involvement

Speed Limit	Rear End		Sideswipe		Other	
	Car-Into-Truck	Truck-Into-Car	Car-Into-Truck	Truck-Into-Car	Car-Into-Truck	Truck-Into-Car
USL: 105 km/h and 88 km/h (65 mph and 55 mph)	10.94	10.78	22.12	21.07	2.57	2.0
DSL: 105/88 km/h and 105/97 km/h (65/55 mph and 65/60 mph)	13.70	6.86	21.52	14.96	2.07	0.99

Overall, the study was not able to isolate or measure the effect of USL/DSL changes. The authors found that the effect of the DSL, if any, is not enough to be detected in the aggregate speed data that were analyzed. In addition, the study found that speed characteristics were generally unaffected by a USL or DSL policy. Except for Virginia, mean speeds tended to increase over the 1990s regardless of whether the State maintained a USL, maintained a DSL, or changed from one to the other. In some cases the increase in speed was significant, in other cases it was not. According to the authors, no consistent safety effects of DSL as opposed to USL were observed within the scope of the study. The mean speed and crash rates tended to increase over the 10-year period, regardless of whether a USL or DSL limit was employed.

A follow-on study attempted different statistical technique, which “showed the crash frequency increasing regardless of whether a state changed from DSL to USL, changed from USL to DSL, maintained USL, or maintained DSL, leading one to conclude that speed limit policy has no consistent impact on safety."[58]

In another study, Garber and Gadiraju found that crash rates increased with increasing speed variance for all classes of roads.[59] In 1964, Solomon studied the relationship between average speed and collision rates of vehicles.[60] He found that the probability of being involved in a crash per vehicle-mile as a function of on-road vehicle speeds follows a U-shaped curve with speed values around the median speed having the lowest probability of being in a crash. In 1968, Julie Cirillo studied vehicles on interstate highways that addressed the impact of speed differential on crashes.[61] The Cirillo study found a U-shaped curve similar to the Solomon curve. In 1971, West and Dunn collected vehicle crash data on a state highway in Indiana with speed limit of 40-50 mph.[62] In their study, since turning vehicles tend to slow down or stop, these crashes were removed from the database. Although a U-shaped pattern was found, the curve was considerably weakened, showing more symmetric crash involvement rates above and below average traffic speeds.

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[58] "The Safety Impacts of Differential Speed Limits on Rural Interstate Highways, A Modified Empirical Bayes Approach, Nicholas J. Garber, John S. Miller, Xin Sun, and Bo Yuan, 2006, Journal of Transportation Engineering, Volume 132 Issue 1.

[59] Garber N.J., and R. Gadiraju. *Speed Variance and its Influence on Accidents*, AAA Foundation for Traffic Safety, July, 1988.

[60] Solomon, David (July 1964, Reprinted 1974). "Accidents on main rural highways related to speed, driver, and vehicle". Technical report, U.S. Department of Commerce/Bureau of Public Roads (precursor to Federal Highway Administration).

[61] Cirillo, J. A. (1968). Interstate System Accident Research Study II, Interim Report II, Public Roads, 35 (3).

[62].West, L.B., Jr. and Dunn, J.W. (1971). "Accidents, Speed Deviation and Speed Limits." *Traffic Engineering*. 41 (10)

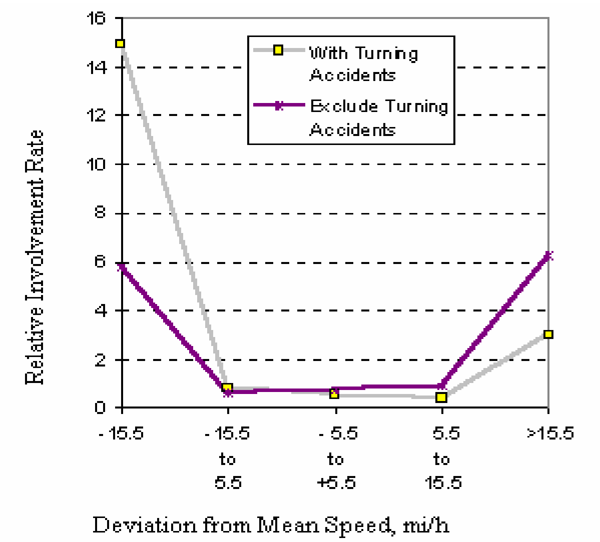

Figure 15. Relationship between Speed and Crash Involvement (West and Dunn, 1971)

The study by University of Arkansas (report # MBTC 2048) shows that the average speed difference between passenger cars and trucks is less than 15 mph without a speed limiting device. For example, the Oklahoma data showed that on average passenger cars travel 2.5 mph higher than trucks on roads with a posted speed limit of 75 mph, 74.8 mph for passenger cars and 72.3 mph for trucks. For example, if 65 mph speed limiting devices are used, we expect that most trucks currently traveling above the set speed of 65 mph would travel at or near 65 mph. Therefore, on average the difference in travel speed between passenger cars and trucks with a 65 mph speed limiting device would be less than 15 mph (for example, in Oklahoma, passenger cars have an average travel speed of 74.8 mph on roads with a posted speed limit of 75 mph). Based on the study by West and Dunn, which showed little change in the crash involvement rate when vehicles were traveling within 15 mph of the mean speed, one would expect the relative crash involvement rate would be relatively unchanged with a 65 mph speed limiting device, since very few highways have posted speed limits of 80 mph or above. Specifically, the speed curve developed by West and Dunn indicated that traveling 5 to 15 mph lower than the median speed is associated with a relative crash involvement rate of 0.71 involvements per million vehicle miles versus 0.8 involvements per million vehicle miles at the median speed. This indicates that, for example, even though limiting heavy vehicles to 65 mph may increase the speed differential between these vehicles and the median travel speed on some roads, 65 mph speed limiting devices may actually reduce the risk of heavy vehicles being involved in a crash on roads with posted speed limits of up to 80 mph (i.e., 15 mph greater than 65 mph). However, we become less confident in this conclusion for set speeds lower than 65 mph.

Finally, an evaluation conducted by the Idaho Department of Transportation found that a change from USL to DSL did not increase crashes.[63]

<u>Decreased Lifetime Fuel Costs Due to Lower Travel Speed</u>:

Research conducted on vehicles designed prior to the joint NHTSA/EPA final rule on medium and heavy duty fuel economy (Phase 1), shows that traveling at lower speeds improves the fuel economy of large vehicles and reduces their greenhouse gas emissions. ATA's Maintenance Council published research in 1996 indicating that each increase in one mph of speed above 55 mph will decrease the fuel efficiency by 0.1 mpg.[64] In a more recent study, the Mack-Blackwell Rural Transportation Center, surveyed carrier fleet maintenance managers, who indicated that an

[63] Idaho Transportation Department Planning Division. *Evaluation of the Impacts of Reducing Truck Speeds on Interstate Highways in Idaho, -Phase III, Final Report* Dec., 2000, National Institute for Advanced Transportation Technology University of Idaho.

[64] ATA Maintenance Council, 55 v. 65+, An Equipment Operating Costs Comparison, 1996.

increase in the operating speed of 1 mph decreases fuel economy by 0.08 mpg to 0.1.[65, 66] Accordingly, in addition to the safety benefits of the rulemaking, the agencies examined the fuel savings from limiting the speed of heavy vehicles.

Potential Effect of NHTSA/EPA Medium and Heavy Duty Fuel Efficiency/GHG Rules

In 2011, EPA and NHTSA, on behalf of the Department of Transportation, finalized rules regulating the fuel efficiency and greenhouse gas emissions of medium- and heavy-duty trucks.[67] Under the rules, the nation's fleet of medium- and heavy-duty trucks is required to meet fuel efficiency and greenhouse gas emission standards for the first time beginning in 2014. For Phase I of the rule, the new program set fuel efficiency and greenhouse gas emission standards for three categories of medium- and heavy-duty trucks beginning in model year 2014. (1) Certain combination tractors will be required to achieve up to approximately 20 percent reduction in fuel consumption and greenhouse gas emissions by model year 2018. (2) Heavy-duty pickup trucks and vans will be required to achieve up to about 15 percent reduction in fuel consumption and greenhouse gas emissions by model year 2018. (3) Vocational vehicles – including delivery trucks, buses, and garbage trucks – will be required to reduce fuel consumption and greenhouse gas emissions by approximately 10 percent by model year 2018.[68]

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[65] Cost-Benefit Evaluation of Large Truck-Automobile Speed Limit Differentials on Rural Interstate Highways, MBTC 2048.

[66] The studies that we examined show that the fuel savings per mph is near constant within the range of speeds our rule considers.

[67] 76 FR 57106 (September 15, 2011).

[68] More information about the Heavy-Duty National Program is available on EPA's web site at: http://www.epa.gov/otaq/climate/regulations htm and on NHTSA's web site at: http://www.nhtsa.gov/fuel-economy.

In July 2015, EPA and NHTSA proposed Phase 2 standards.[69] If finalized, these standards would, in addition to the vehicles covered by Phase 1, include trailer standards beginning with model year 2018. For other vehicle types, the new standards would begin with model year 2021 and would culminate in standards for model year 2027. Certain combination trucks/tractors (or tractor trailers) will be required to achieve up to approximately 24 percent reduction in fuel consumption and greenhouse gas emissions compared to model year 2018 vehicles. Vocational vehicles – including delivery trucks, buses, and garbage trucks – will be required to reduce fuel consumption and greenhouse gas emissions by approximately 16 percent.

The VMT and fuel economy values were determined using Federal Highway Administration (FHWA) data.[70] FHWA data from 2013 indicate that combination trucks traveled a total of 87,484 million miles on rural and urban interstates and had an average fuel economy of 5.8 mph on highways. We estimate that class 7 & 8 single unit trucks traveled a total of 4,629 million miles on interstates and had an average fuel economy of 7.3 mpg.[71] Finally, buses traveled a total of 3,658 million miles on interstates and had an average fuel economy of 7.2 mpg. To adjust for the anticipated effects of the Phase 1 fuel economy rulemaking, we adjusted the FHWA average fuel economy estimates upward. Thus, the combination truck fuel economy was

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[69] 80 FR 40137 (July 13, 2015).

[70] U.S. Department of Transportation, Federal Highway Administration, Highway Statistics 2013, available at www.fhwa.dot.gov. The agencies recognize that these average fuel economies are for a single year (2013) and note that our fuel savings estimates are impacted by these values (i.e., different assumptions about the average fuel economy of heavy vehicles would change the estimated fuel savings).

[71] According to Transportation Energy data Book, Edition 32, 569,000 Class 3- 8 trucks were sold in 2012. Among the 569,000 trucks, NHTSA estimated that 150,000 were combination trucks (FMVSS No. 136, PRIA) and 75,000 were Class 7 & 8 single unit trucks. Thus, we estimated that 344,000 Class 3-6 truck would be sold annually. The total number of Class 3-8 single unit truck would be 419,000 (75,000 + 344,000 = 419,000). Thus, we estimated that 18% of single unit trucks would be Class 7-8 (75,000/419,000 = 18%). The 2013 FHWA data show a total of 24.765 VMT for single unit trucks. For the analysis, the target VMT would be 4,458 (24,765 x 18% = 4,458).

adjusted upward by 20 percent, the single unit truck fuel economy was adjusted upward by 15 percent, and bus fuel economy was adjusted upward by 10 percent.

If adopted, this proposed rule would affect the same vehicles and would likely take effect shortly before the phase 2 fuel economy requirements would, if adopted, take effect. In order to examine the effect of this speed limiter proposed rule in combination with the phase 2 fuel economy rulemaking, we have created a separate baseline based on the proposed phase 2 fuel economy requirements. For the phase 2 baseline, we have adjusted the expected phase 1 combination fuel economy upward by 24 percent and the expected phase 1 single unit and bus fuel economy upward by 15 percent.

For roads with posted limits of 55 mph+, the agencies estimated the current VMT by heavy vehicles, the vehicles' travel speeds, and the vehicles' fuel economy (mpg) at each speed. These values were estimated for five categories of roads: 55 mph roads, 60 mph roads, 65 mph roads, 70 mph roads, and 75 mph+ roads. The agencies then analyzed the effect of limiting heavy vehicles on these roads on fuel economy. The agencies used a two-step approach to estimate the fuel saving considering the latest EPA final rule and the lack of "on-road, with real vehicles" research into the vehicle fuel efficiency performance related to speed changes. First, the agencies assumed that a decrease in operating speed of 1 mph increases fuel economy by 1.37%, consistent with the results of the of the survey of commercial fleet managers conducted by the Mack-Blackwell Rural Transportation Center. This percentage represents the 0.08 mpg improvement per 1 mph of speed increase, which was the lower end of the Mack-Blackwell estimate, divided by the 5.85 mpg FHWA-estimated average fuel economy. We believe this is a conservative (meaning lower) estimate of the effect of reducing speed on fuel economy.

We have also considered how the fuel economy rulemakings affect the relationship between lower travel speeds and fuel economy. We considered, for example, whether the aerodynamic improvements in the proposed phase 2 fuel economy requirements would reduce the magnitude of the improvement of a 1 mph reduction on speed on fuel economy. To evaluate the effect of a speed limiter on the fuel economy of a combination truck, we contracted with Southwest Research Institute (SwRI), which had provided simulation data supporting the phase 2 proposal, to conduct simulations of the effect of speed limiters on fuel economy.[72]

A series of vehicle simulation runs were completed using a model of a Kenworth T700 tractor, combined with a 53-foot box van trailer. This vehicle model was extensively evaluated in a program conducted by SwRI to inform NHTSA and EPA's development of Phase 2 proposal. The simulations were run over a range from 60 mph to 80 mph, in 1 mph steady speed increments. Two types of road were simulated: level ground, and rolling terrain. The grade simulation was based on a grade profile used in the Phase 2 NPRM (Figure III-2) and it was run both forward and backward because the grade has an overall decrease in elevation of approximately 50 meters.[73] Each vehicle configuration and speed was run over a range of five payloads: 0 percent (empty), 50 percent, 100 percent, 38,000 pounds (GEM payload),[74] and 42,000 pounds.[75]

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[72] See Appendix J
[73] 80 FR 40248.
[74] The GEM payload represents the payload used in EPA's GEM compliance modeling.
[75] This payload represents an average combination truck payload based on FHWA data. See http://ops fhwa.dot.gov/wz/resources/publications/fhwahop12005/sec2 htm.

The level ground results show a nearly linear relationship between road speed and fuel economy (i.e., MPG) over the range of 60 to 80 MPH. The speed sensitivity is greatest at zero payload, and least at 100% payload. This makes sense, because aerodynamic drag is independent of payload, but highly dependent on speed, while rolling resistance is related to payload. Power demand due to rolling resistance increases linearly with speed, while power demand due to aerodynamic drag increases with speed cubed. Thus, if other factors are held constant, a truck with a higher coefficient of drag value will have a greater sensitivity of fuel economy to speed.

Figure 16 shows the relationship between cruise speed and fuel economy for the 2018 tractor-trailer on the level ground drive cycles, and Figure 16 provides the same relationships for the drive cycles with grades. In Figure 16, the vehicle with zero payload is able to run the cycles at the target speeds, but as payload increases, speed drops on the uphill segments. Therefore, the results shown in Figure 17 show the actual achieved cycle average speeds, which at full load can be as much as 1.6 MPH less than the target speed. Figures 18 and 19 provide the results for the 2027 vehicle with and without grades. As expected, the 2027 vehicle gets better fuel economy. In comparing Figures 18 and 19, the impact of the cycle with grade is minimal for the zero payload case. The average speeds and the fuel economy are almost identical with and without grades. However, as payload increases, the average speed on the cycles with grade starts to fall, and fuel economy is also reduced, especially at the lower speeds.

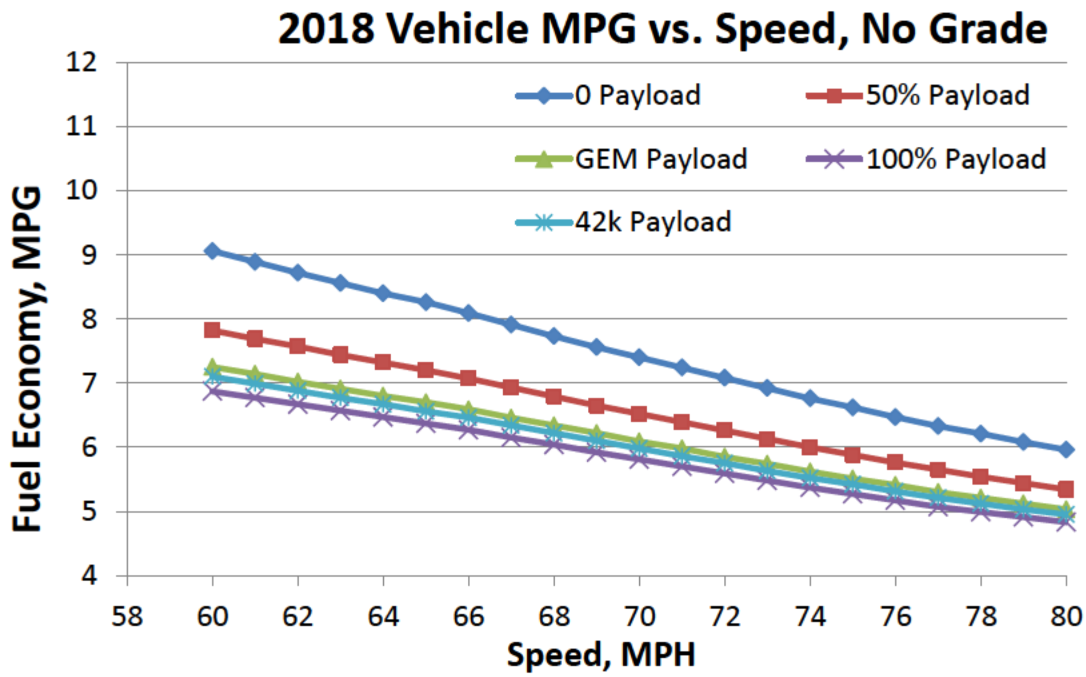

Figure 16 2018 vehicle fuel economy sensitivity to speed, over a range of payloads, with zero grade.

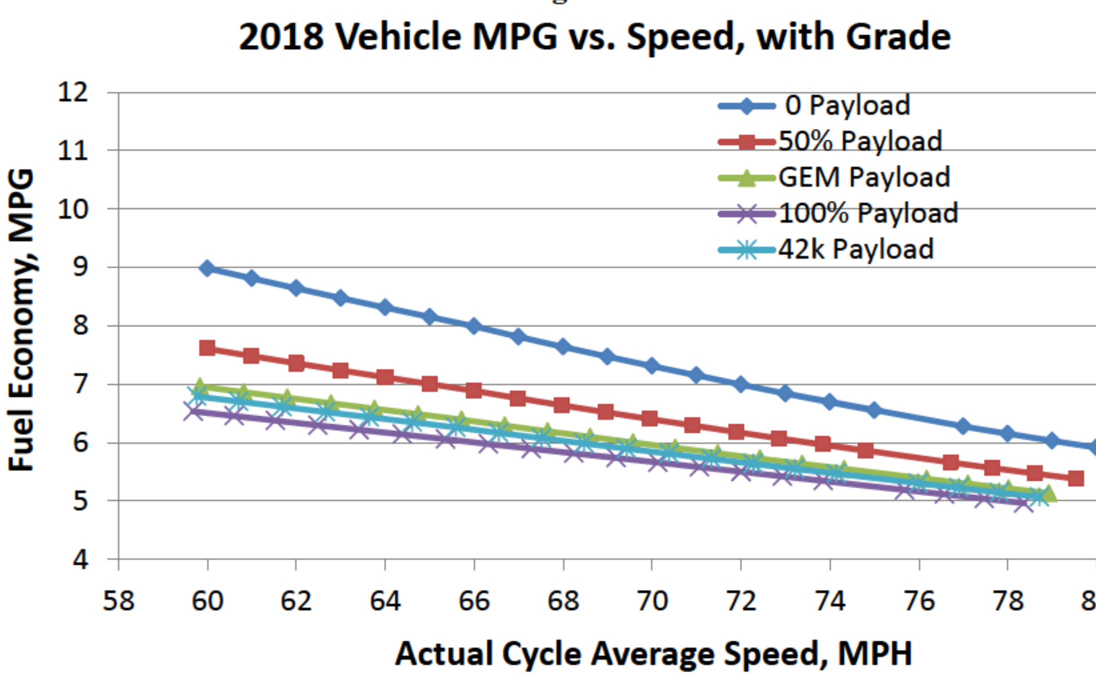

Figure 17 2018 vehicle fuel economy sensitivity to speed, over a range of payloads, with grades.

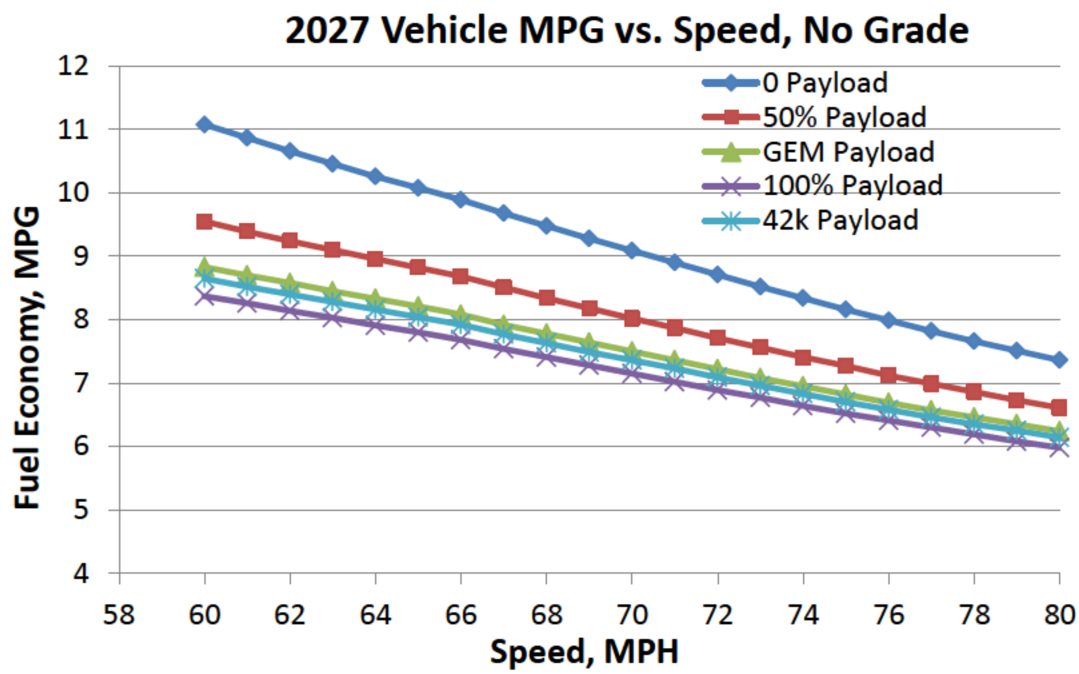

Figure 18 2027 vehicle fuel economy sensitivity to speed, over a range of payloads, with zero grade.

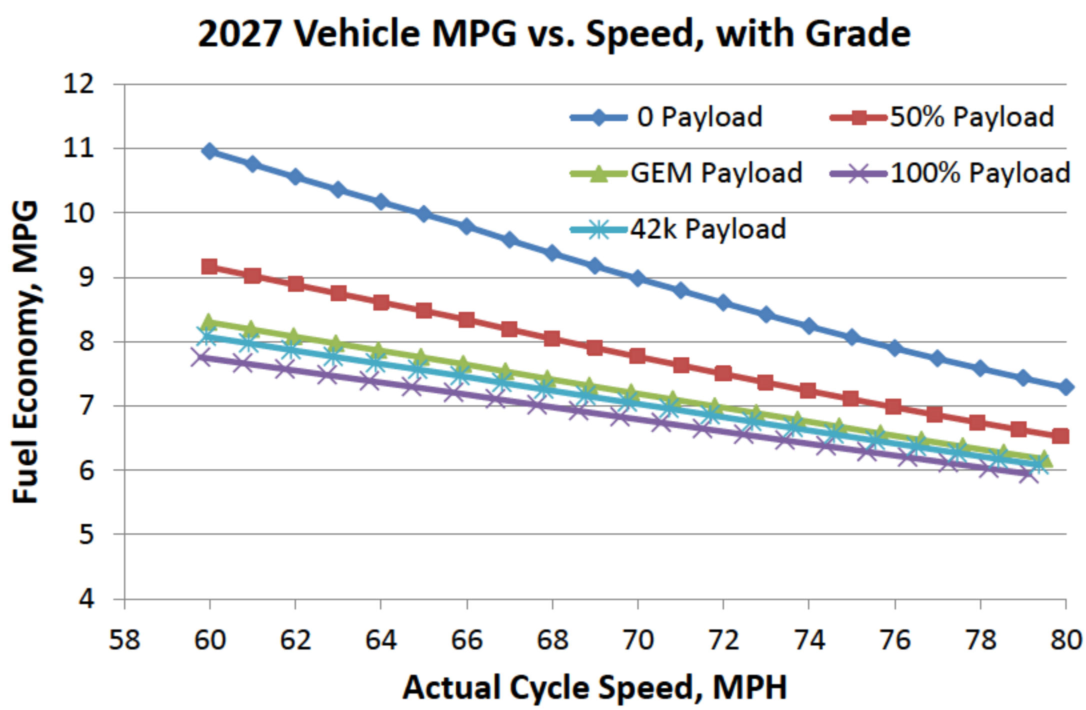

Figure 19 2027 vehicle fuel economy sensitivity to speed, over a range of payloads, with grades.

The results showed that the magnitude of the improvement in fuel efficiency resulting from a decrease in speed was affected by the proposed phase 2 standards. However, the magnitude of the improvement in fuel economy from a 1 mph reduction in speed exceeded our 1.37% estimates. This indicates that our fuel savings estimates are conservative estimates. Table 64 summarizes the improvements in fuel economy from a 1 mph speed reduction using the 42,000 pound load estimate. The speed in each row corresponds to the percentage improvement in fuel economy resulting from a 1 mph speed reduction to that speed. For example, the row with a speed of 65 represents the percentage improvement in fuel economy resulting from a 1 mph speed reduction from 66 mph to 65 mph. At the bottom, the average improvement over the full range of speeds is shown, as well as the average improvement between 75 mph and 65 mph.

Table 64
Simulated increase in fuel economy resulting from a 1 mph reduction in speed (42,000 pound payload)

Speed	**Phase 1 flat**	**Phase 2 flat**		**Phase 1 hill**	**Phase 2 hill**
60	1.574%	1.526%		1.271%	1.296%
61	1.599%	1.429%		1.374%	1.321%
62	1.625%	1.449%		1.369%	1.315%
63	1.499%	1.471%		1.369%	1.314%
64	1.677%	1.493%		1.376%	1.305%
65	1.548%	1.515%		1.415%	1.341%
66	1.893%	1.931%		1.509%	1.452%
67	1.929%	1.835%		1.507%	1.422%
68	1.967%	1.869%		1.508%	1.412%
69	2.007%	1.766%		1.510%	1.407%
70	2.048%	1.798%		1.497%	1.415%
71	1.913%	1.975%		1.529%	1.470%
72	2.131%	1.868%		1.528%	1.484%
73	1.993%	1.903%		1.538%	1.492%
74	1.845%	1.940%		1.532%	1.503%
75	2.072%	1.824%		1.520%	1.514%
76	1.919%	1.858%		1.523%	1.514%
77	1.758%	1.732%		1.547%	1.527%
78	1.789%	1.600%		1.550%	1.525%

79	1.616%	1.792%		1.516%	1.500%
Average over all speeds	**1.820%**	**1.729%**		**1.474%**	**1.426%**
Average over 75 to 65	**1.940%**	**1.839%**		**1.509%**	**1.446%**

Based on all of the available information, we are using an estimate of 1.37% improvement in fuel economy per 1 mph reduction in speed reported in the Mack-Blackwell study. While the available data, including the simulation results, could justify a higher percentage improvement per mph, the Mack-Blackwell study, supported by other literature, is indicative of real world fuel savings estimates. We believe it represents a conservative estimate of the expected fuel savings that would result from a 1 mph speed reduction, even after considering the proposed phase 2 fuel economy standards.

Estimating VMT at each posted speed limit:

In order to estimate the VMT at each posted speed limit, the agencies used GES crash data. [76] Specifically, we assumed that all rural and urban interstates with a particular posted speed limit (e.g., 55 mph) had the same crash risk and that, therefore, the number of crashes on roads with that particular posted speed limit would be proportional to the number of vehicle miles traveled on those roads (i.e., crash exposure). Under the assumption, we used the crash frequency as a proxy for travel volume to estimate VMT.

[76] The agencies used the target population derived solely from GES data occurring on interstate roads with a posted speed limit of 55 mph and above for this analysis.

Table 65
Combination truck crash rate by posted speed limit, Interstate, 2004 - 2013 GES, 10 years

Crashes	Speed Limit					
	55	60	65	70	75	Total
Vehicles Involved in Police Reported Crashes	35,643	19,613	34,957	32,433	17,166	139,812
Estimated % VMT	25%	14%	25%	23%	12%	100%

As indicated above, combination trucks traveled 87,484 million miles (VMT) on rural and urban interstates. Based on the 2004 - 2013 FARS data, we estimated that 98% of combination trucks have a GVWR of 26,000 lbs and greater. In addition, based on the 2004 - 2013 GES data, we estimated that 95% of crashes occur at a posted speed of 55 mph – 75 mph.

Similar to the approach used to determine safety benefits, combination truck and single unit truck travel speeds were based on the speeds observed on 20 rural interstate highways in 13 states.[77]

Table 66
Heavy truck observed average speeds on rural highways[78]

State	Posted speed (mph)	Sample size	Observed Speed (mph)	Std. Dev. (mph)
California	55	277	61.2	3.62
Illinois	55	262	64.2	4.00
Oregon	55	273	60.9	2.87
Washington	60	139	63.3	3.04
Washington	60	154	64.5	2.67
Washington	60	246	62.9	3.28

[77] Johnson, S. & Murray D., Empirical Analysis of Truck and Automobile Speeds on Rural Interstates: Impact of Posted Speed Limits, July 2009; Johnson, Steven L. & Pawar, Naveen, Mack-Blackwell Rural Transportation Center, College of Engineering, University of Arkansas, Cost-Benefit Evaluation of Large Truck-Automobile Speed Limits Differentials on Rural Interstate Highways, MBTC 2048 (Nov. 2005). Our benefits assessment is based upon lowering the speeds of those trucks currently travelling over 65 mph to 65 mph based on the distribution of speeds observed in the study. Thus, regulating maximum, rather than average, speed has no effect on our analysis.

[78] If we assume vehicle travel speeds are distributed by the Normal distribution, the Illinois state data indicate that most of trucks were speeding on roads with a posted speed limit of 55 mph and that about 50% of these trucks were travelling at a speed higher than 65 mph.

Connecticut	65	184	66.4	3.80
Connecticut	65	156	66.0	3.16
Connecticut	65	212	66.1	3.44
South Carolina	65	433	67.2	4.12
Arkansas	65	169	66.7	3.69
South Carolina	70	276	69.0	4.00
Missouri	70	247	68.6	4.55
Texas	70	131	68.6	3.63
Oklahoma	70	168	69.4	3.38
New Mexico	75	36	68.9	5.97
New Mexico	75	276	68.0	4.20
Oklahoma	75	33	72.3	5.63
South Dakota	75	193	67.0	4.00
Wyoming	75	140	69.8	4.85

We combined the speed observations by speed limit taking the average of the observed speeds in each speed limit zone weighted by the number of observations. We also combined the standard deviations of each posted speed limit, assuming each observation set was normally distributed, by taking the root mean square of the standard deviations, again weighted by the number of observations. The mean speed and standard deviation for each posted speed limit are summarized in the table below.

Table 67
Heavy truck observed average speeds on rural highways

Posted speed (mph)	Observed Speed (mph)	Std. Dev. (mph)
55	62.1	3.52
60	63.5	3.05
65	66.6	3.77
70	68.9	4.00
75	68.3	4.48

We note that the average observed speed on roads with a posted speed limit of 75 mph is slightly (about 0.6 mph) lower than the observed speed on roads with a posted speed limit of 70 mph. We believe that this may reflect that 68-69 mph represents the fastest average speed trucks will travel regardless of the posted speed limit. That is, we anticipate that on roads with posted speed limits of 80 mph or greater, it is unlikely the average truck speed would increase substantially.

Using the mean speed and standard deviation, we created normal distributions of travel speed for each posted speed limit. The distribution represented the fraction of miles traveled on each posted speed limit at all travel speeds from 45 to 85 mph in increments of 1 mph.

Table 68
Estimated distribution of combination truck VMT on highways

Travel speed (mph)	Fraction of 55 mph travel	Fraction of 60 mph travel	Fraction of 65 mph travel	Fraction of 70 mph travel	Fraction of 75 mph travel
45	0.0000	0.0000	0.0000	0.0000	0.0000
46	0.0000	0.0000	0.0000	0.0000	0.0000
47	0.0000	0.0000	0.0000	0.0000	0.0000
48	0.0000	0.0000	0.0000	0.0000	0.0000
49	0.0001	0.0000	0.0000	0.0000	0.0000
50	0.0003	0.0000	0.0000	0.0000	0.0000
51	0.0008	0.0000	0.0000	0.0000	0.0000
52	0.0019	0.0001	0.0001	0.0000	0.0001
53	0.0041	0.0004	0.0002	0.0000	0.0003
54	0.0082	0.0011	0.0004	0.0001	0.0005
55	0.0151	0.0028	0.0009	0.0002	0.0011
56	0.0257	0.0066	0.0020	0.0006	0.0020
57	0.0402	0.0140	0.0040	0.0012	0.0036
58	0.0582	0.0264	0.0077	0.0025	0.0062
59	0.0775	0.0450	0.0136	0.0047	0.0101
60	0.0953	0.0688	0.0225	0.0084	0.0157
61	0.1082	0.0944	0.0346	0.0142	0.0232
62	0.1132	0.1165	0.0497	0.0226	0.0327
63	0.1093	0.1291	0.0665	0.0337	0.0437
64	0.0974	0.1286	0.0829	0.0471	0.0557
65	0.0801	0.1150	0.0964	0.0620	0.0674
66	0.0607	0.0924	0.1044	0.0767	0.0777
67	0.0425	0.0667	0.1054	0.0891	0.0852
68	0.0274	0.0433	0.0992	0.0972	0.0888
69	0.0163	0.0252	0.0870	0.0996	0.0881
70	0.0090	0.0132	0.0711	0.0959	0.0832
71	0.0045	0.0062	0.0541	0.0868	0.0747
72	0.0021	0.0026	0.0384	0.0738	0.0638
73	0.0009	0.0010	0.0254	0.0590	0.0519
74	0.0004	0.0003	0.0157	0.0442	0.0401
75	0.0001	0.0001	0.0090	0.0312	0.0295
76	0.0000	0.0000	0.0048	0.0207	0.0207
77	0.0000	0.0000	0.0024	0.0129	0.0138

78	0.0000	0.0000	0.0011	0.0075	0.0087
79	0.0000	0.0000	0.0005	0.0041	0.0053
80	0.0000	0.0000	0.0002	0.0021	0.0030
81	0.0000	0.0000	0.0001	0.0010	0.0016
82	0.0000	0.0000	0.0000	0.0005	0.0009
83	0.0000	0.0000	0.0000	0.0002	0.0004
84	0.0000	0.0000	0.0000	0.0001	0.0002
85	0.0000	0.0000	0.0000	0.0000	0.0001

We used those distributions to allocate the VMT for each posted speed limit. For example, according to the 2013 VMT data, combination trucks traveled 87,484 million miles on rural and urban interstates in 2013. With the adjustment, we estimated combination trucks with a GVWR of 26,000 lbs and greater traveled 81,778 million miles on rural and urban interstates with a posted speed limit of 55 mph – 75 mph. Among the 81,778 million miles, we estimated the proportion of total VMT at each speed limit as shown above. We used the fractions derived from the distributions in order to establish the VMT at each travel speed for each posted speed limit.

Table 69
Estimated combination truck VMT, in millions of miles, on highways with a posted speed of 55 mph or greater by speed.

Travel speed (mph)	55 mph speed limit	60 mph speed limit	65 mph speed limit	70 mph speed limit	75 mph speed limit	Total VMT
45	0.02	0.00	0.00	0.00	0.00	0.02
46	0.08	0.00	0.00	0.00	0.00	0.08
47	0.27	0.00	0.00	0.00	0.01	0.28
48	0.87	0.00	0.01	0.00	0.03	0.92
49	2.60	0.02	0.04	0.01	0.09	2.75
50	7.15	0.10	0.13	0.03	0.22	7.63
51	18.17	0.39	0.42	0.09	0.53	19.60
52	42.57	1.41	1.22	0.27	1.23	46.70
53	92.02	4.56	3.31	0.76	2.70	103.36
54	183.52	13.26	8.35	1.99	5.67	212.79
55	337.67	34.63	19.65	4.89	11.30	408.14
56	573.20	81.26	43.06	11.28	21.44	730.23
57	897.68	171.31	87.96	24.44	38.69	1220.08
58	1297.02	324.44	167.43	49.76	66.44	1905.09

59	1728.92	552.02	297.04	95.20	108.53	2781.71
60	2126.23	843.80	491.11	171.10	168.68	3800.92
61	2412.41	1158.76	756.73	288.93	249.40	4866.24
62	2525.20	1429.60	1086.67	458.40	350.83	5850.70
63	2438.64	1584.53	1454.27	683.27	469.50	6630.22
64	2172.73	1577.81	1813.80	956.86	597.75	7118.95
65	1785.95	1411.47	2108.29	1258.95	724.03	7288.68
66	1354.37	1134.38	2283.83	1556.22	834.33	7163.13
67	947.57	819.04	2305.65	1807.34	914.68	6794.29
68	611.63	531.28	2169.29	1972.04	953.99	6238.23
69	364.23	309.61	1902.12	2021.59	946.61	5544.15
70	200.11	162.09	1554.36	1947.05	893.60	4757.20
71	101.43	76.24	1183.75	1761.84	802.53	3925.78
72	47.43	32.21	840.16	1497.82	685.69	3103.31
73	20.46	12.23	555.73	1196.35	557.37	2342.13
74	8.14	4.17	342.57	897.76	431.02	1683.67
75	2.99	1.28	196.81	632.95	317.11	1151.13
76	1.01	0.35	105.37	419.26	221.96	747.95
77	0.32	0.09	52.58	260.91	147.80	461.69
78	0.09	0.02	24.45	152.55	93.63	270.74
79	0.02	0.00	10.60	83.80	56.43	150.86
80	0.01	0.00	4.28	43.25	32.36	79.89
81	0.00	0.00	1.61	20.97	17.65	40.23
82	0.00	0.00	0.57	9.55	9.16	19.28
83	0.00	0.00	0.18	4.09	4.52	8.80
84	0.00	0.00	0.06	1.64	2.12	3.82
85	0.00	0.00	0.02	0.62	0.95	1.59
Total VMT	22,303	12,272	21,874	20,294	10,741	87,484

From this data, we were able to calculate an average combination truck travel speed of 65.4 mph on all roads with a posted speed of 55 mph or greater. For the fuel saving analysis, we assumed that the average fuel efficiency based on the FHWA estimate of 5.85 mpg at an average speed of 65.4 mph. We began by calculating the base fuel economy at a speed of exactly 65 mph by adjusting the fuel economy up by .4 * 1.37%. Thus, the assumed 65 mph fuel efficiency based on FHWA data was 5.88 mpg.

We then considered the effect of EPA and NHTSA's CAFE rulemaking on fuel economy. For combination trucks, we estimated that phase 1 would result in 20 percent overall improvement in fuel economy. Thus, we adjusted the base 65 mph fuel economy up by 20 percent to estimate the post-phase 1 truck fuel efficiency 7.06 mpg at 65 mph.

We have also considered the effect of the proposed phase 2 fuel economy standards on this proposal. If adopted, this proposal and the proposed phase 2 fuel economy requirements would affect the same vehicles at nearly the same time. In order to examine the effect of the phase 2 fuel economy rulemaking on the proposed speed limiter requirements, we have created a separate baseline based on the proposed phase 2 fuel economy requirements. For the phase 2 baseline, we have adjusted the expected phase 1 combination fuel economy upward by 24 percent. Thus, if the proposed phase 2 standards are adopted, we estimate combination trucks would achieve 8.76 mph at 65 mph.

The agencies then assumed that fuel economy would increase by 1.37% for each 1 mph reduction in speed below 65 mph and that fuel economy would decrease by 1.37% for each 1 mph above 65 mph. Using this assumption, the agencies were able to determine expected VMT at each speed using both a phase 1 CAFE baseline and a proposed phase 2 CAFE baseline. These fuel economy estimates are presented in the next table for speeds of 65 mph and above. We then used the fuel economy estimates and the total VMT at each travel speed calculated above to determine the amount of fuel consumed at each travel speed.

Table 70
Estimated fuel economy and fuel consumption for combination trucks by speed

Travel speed (mph)	VMT, in millions of miles	Phase 1 fuel economy, in mpg	Phase 1 baseline fuel consumption, in millions of	Proposed phase 2 fuel economy, in mpg	Proposed phase 2 baseline fuel consumption,

			gallons		in millions of gallons
65	6,813	7.06	964.96	8.76	778.19
66	6,696	6.96	961.49	8.64	775.39
67	6,351	6.87	924.63	8.52	745.67
68	5,831	6.77	860.72	8.40	694.13
69	5,183	6.68	775.57	8.29	625.46
70	4,447	6.59	674.71	8.17	544.12
71	3,670	6.50	564.51	8.06	455.25
72	2,901	6.41	452.43	7.95	364.86
73	2,189	6.32	346.19	7.84	279.19
74	1,574	6.24	252.32	7.73	203.48
75	1,076	6.15	174.90	7.63	141.05
76	699	6.07	115.22	7.52	92.92
77	432	5.99	72.11	7.42	58.15
78	253	5.90	42.87	7.32	34.57
79	141	5.82	24.22	7.22	19.53
80	75	5.74	13.00	7.12	10.49
81	38	5.66	6.64	7.02	5.35
82	18	5.59	3.23	6.93	2.60
83	8	5.51	1.49	6.83	1.20
84	4	5.44	0.66	6.74	0.53
85	1	5.36	0.28	6.65	0.22
Total	48,399		7232.13		5,832.36

To estimate the fuel savings from 65 mph speed limiters, for example, the agencies assumed that all VMT currently occurring at speeds greater than 65 mph would occur at 65 mph. Thus, instead of the 6,813 million VMT occurring at 65 mph based on this estimate, there would be 48,399 million VMT at 65 mph. Using the estimated 65 mph fuel economy for both the phase 1 CAFE baseline and the proposed phase 2 CAFE baseline, the agencies were able to estimate the amount of fuel that would be consumed at 65 mph.

Table 71
Estimated fuel consumption for combination trucks at 65 mph using a 65 mph speed limiting device

Travel speed (mph)	VMT, in millions	Phase 1 fuel	Phase 1 fuel consumption,	Proposed phase 2	Proposed phase 2 fuel

	of miles	economy, in mpg	in millions of gallons*	fuel economy, in mpg	consumption, in millions of gallons
65	48,399	7.06	6,854.79	8.76	5,528.06

* 48,399 VMT/7.06 mpg = 6,854.79

The impact of speed limiting devices is dependent on the difference between the maximum travel speed set by speed limiting devices and the speeds that the vehicle would have traveled above the speed limiting device setting. The difference between the baseline fuel consumption at speeds of 65 mph above and the fuel that would be consumed at 65 mph assuming the use of a 65 mph speed limiting device represents the fuel savings that would result from using 65 mph speed limiter. This fuel savings from the two baseline conditions are summarized in the following table.

Table 72
Estimated fuel savings using a 65 mph speed limiting device on combination trucks, in millions of gallons

	Phase 1 baseline	Proposed phase 2 baseline
Baseline fuel consumed at speeds ≥ 65 mph	7,232.13	5,832.36
Estimated fuel consumed at 65 mph using speed limiter	6,854.79	5,528.06
Estimated fuel savings as a result of 65 mph speed limiter	377.34	304.3

Thus, with 65 mph speed limiter on combination trucks, we expect speed limiters to result in a 377 million gallon reduction in fuel consumption assuming a phase 1 CAFE baseline and a 304 million gallon reduction in fuel consumption assuming a proposed phase 2 CAFE baseline. To monetize the fuel savings, the agencies relied upon the 2015 Annual Energy Outlook (AEO), published by the U.S. Energy Information Administration.[79] The agencies examined fuel price predictions over the lifetime of the vehicle. The agencies also considered fuel prices both before and after taxes. Pre-tax fuel price represents the best estimate of the societal benefit resulting from decreased fuel consumption. Fuel taxes themselves represent transfers of wealth rather than societal costs. However, we also considered the after-tax fuel price estimate in order to consider the effect of this proposal on truck fleets. Appendix J provides detail how the agencies calculated the fuel price estimates. We calculated that, over the life of a combination truck, the average diesel fuel price would be $3.233 per gallon exclusive of taxes and $3.663 per gallon including taxes. The following tables provide the estimated fuel savings for combination trucks using both baselines.

Table 73
Estimated societal fuel savings for combination trucks ($2013 in millions), with a 65 mph speed limiter

Baseline	Fuel, in millions of gallons	$, no discount	3%	7%
Phase 1	377	$1,220	$988	$784
Proposed phase 2	304	$984	$796	$632

Table 74
Estimated fleet fuel savings for combination trucks ($2013 in millions), with a 65 mph speed limiter

Baseline	Fuel, in millions of	$, no discount	3%	7%

[79] See http://www.eia.gov/forecasts/aeo/

	gallons			
Phase 1	377	$1,382	$1,119	$888
Proposed phase 2	304	$1,115	$902	$716

For single unit trucks and buses, we used the same methodology and data sources we used for combination trucks. Based on the 2013 VMT data and the sales data, the agencies estimate that Class 7 and 8 single unit trucks traveled 10,821 million miles on rural and urban interstates and buses traveled 2,624 million miles on rural and urban interstates on a posted speed limit of 55 mph – 75 mph. For single unit trucks, we considered that those vehicles may be powered by either diesel or gasoline. When separated by fuel type (i.e., gasoline and diesel), 23% of the VMT were from gasoline single unit trucks and the remaining 77% were from diesel single unit trucks based on a 2002 Bureau of Transportation Statistics analysis.[80]

Using the same approach that we used for combination trucks, with 65 mph speed limiters, we estimate that the fuel savings for single unit trucks would be 36 million gallons using a phase 1 baseline and 32 million gallons using the proposed phase 2 baseline. Using an estimated gasoline price of $2.699 per gallon pretax and an estimated diesel price of $3.233 per gallon pretax, we have calculated societal fuel savings of $113 million annually using the phase 1 baseline and $98 million annually using the proposed phase 2 baseline. With an estimated gasoline of $3.081 per gallon after tax and an estimated diesel price of $3.663 per gallon after tax, single unit truck fleets would realize $128 million in fuel savings using the phase 1 baseline and $111 million in fuel savings using the proposed phase 2 baseline.

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[80] http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/bts_fact_sheets/oct_2015/html/table_01 html

For buses, with 65 mph speed limiters, we estimate the fuel savings would be 9 million gallons using a phase 1 baseline and 8 million gallons using a proposed phase 2 baseline. Using the diesel price assumptions for combination trucks, this would result in societal savings of $30 million using the phase 1 baseline and $26 million using the proposed phase 2 baseline. Bus fleets would realize $34 million in savings using the phase 1 baseline and $30 million in savings using the proposed phase 2 baseline.

When all posted speed limits of 55 mph, 60 mph, 65 mph, 70 mph, and 75 mph and all vehicle types are considered, a total of 423 million gallons of fuel would be saved with a 65 mph speed limiting device using the phase 1 baseline and 344 million gallons of fuel would be saved using the proposed phase 2 baseline.

Table 75
Summary of annual **societal** fuel saving with 65 mph speed limiting device (in millions of gallons & 2013 dollars) assuming Phase 1 CAFE baseline

Vehicle Type	Fuel and $ savings			
	Fuel (mil. of gal.)	no-discount	3%	7%
Combination truck	377	$1,220	$988	$784
Single unit truck	36	$113	$91	$73
Bus	9	$30	$24	$19
Total	423	$1,363	$1,103	$876

Table 76
Summary of annual **societal** fuel saving with 65 mph speed limiting device (in millions of gallons & 2013 dollars) assuming proposed Phase 2 CAFE baseline

Vehicle Type	Fuel and $ savings			
	Fuel (mil. of gal.)	no-discount	3%	7%
Combination truck	304	$984	$796	$632
Single unit truck	32	$98	$80	$63
Bus	8	$26	$21	$17
Total	344	$1,108	$897	$712

Table 77
Summary of annual **fleet** fuel saving with 65 mph speed limiting device (in millions of gallons & 2013 dollars) assuming Phase 1 CAFE baseline

Vehicle Type	Fuel and $ savings			
	Fuel (mil. of gal.)	no-discount	3%	7%
Combination truck	377	$1,382	$1,119	$888
Single unit truck	36	$128	$104	$82
Bus	9	$34	$28	$22
Total	423	$1,544	$1,250	$993

Table 78
Summary of annual **fleet** fuel saving with 65 mph speed limiting device (in millions of gallons & 2013 dollars) assuming proposed Phase 2 CAFE baseline

Vehicle Type	Fuel and $ savings			
	Fuel (mil. of gal.)	no-discount	3%	7%
Combination truck	304	$1,115	$902	$716
Single unit truck	32	$111	$90	$72
Bus	8	$30	$24	$19
Total	344	$1,256	$1,017	$807

We have also conducted an identical analysis using a 68 mph speed limiter option. Those results are summarized below.

Table 79
Summary of annual **societal** fuel saving with 68 mph speed limiting device (in millions of gallons & 2013 dollars) assuming Phase 1 CAFE baseline

Vehicle Type	Fuel and $ savings			
	Fuel (mil. of gal.)	no-discount	3%	7%
Combination truck	169	$545	$441	$350
Single unit truck	15	$48	$39	$31
Bus	4	$12	$10	$8
Total	188	$605	$490	$389

Table 80
Summary of annual **societal** fuel saving with 68 mph speed limiting device (in millions of gallons & 2013 dollars) assuming proposed Phase 2 CAFE baseline

Vehicle Type	Fuel and $ savings			
	Fuel (mil. of gal.)	no-discount	3%	7%
Combination truck	136	$440	$356	$283
Single unit truck	13	$41	$34	$27
Bus	3	$11	$9	$7
Total	153	$492	$398	$316

Table 81

Summary of annual **fleet** fuel saving with 68 mph speed limiting device (in millions of gallons & 2013 dollars) assuming Phase 1 CAFE baseline

Vehicle Type	Fuel and $ savings			
	Fuel (mil. of gal.)	no-discount	3%	7%
Combination truck	169	$618	$500	$397
Single unit truck	15	$54	$44	$35
Bus	4	$14	$11	$9
Total	188	$685	$555	$440

Table 82

Summary of annual **fleet** fuel saving with 68 mph speed limiting device (in millions of gallons & 2013 dollars) assuming proposed Phase 2 CAFE baseline

Vehicle Type	Fuel and $ savings			
	Fuel (mil. of gal.)	no-discount	3%	7%
Combination truck	136	$498	$403	$320
Single unit truck	13	$47	$38	$30
Bus	3	$12	$10	$8
Total	153	$557	$451	$358

As noted above, because the medium- and heavy-duty fuel economy rule accounted for the fuel savings from using speed limiting devices to limit the speed of heavy vehicles from 65 mph to a lower speed, no additional fuel savings from limiting heavy vehicle speeds below 65 mph are estimated. No additional fuel savings from a set speed below 65 mph could be attributed to this rulemaking without double-counting the benefits of the heavy-duty vehicle fuel efficiency program.[81] If the CAFE credit is not considered, a 60 mph speed limiter would save 1,082

[81] If the maximum travel speed is limited to 65 mph, any vehicle speed limiting device with a setting greater than this will not result in fuel savings that can be attributed to this rule. For vehicle speed limiters set below 65 mph, the CAFE program allows manufacturers to set speed limiters at speeds below 65 mph in order to achieve compliance. For illustration, without the speed limiters rule, truck-tractor manufacturers may not use a speed limiter set at speeds below 65 mph. Instead of using speed limiters, these manufacturers have utilized new/other technologies for the CAFE compliance. However, if the speed limiters rule requires 60 mph maximum set speed, almost all

million gallons annually using the phase 1 baseline and 877 million gallons annually using the proposed phase 2 baseline.

As part of the Environmental Assessment, the agencies ran the MOVES2014a model using the national scale domain, which is described in the technical support documents on EPA's website. To model various set speeds, the agencies modified the "Average Speed Distribution" input parameter for each set speed based on the speed distributions used throughout this document. The model's outputs included emissions and fuel consumption. The fuel consumption results of this analysis provide a rough gauge by which the fuel consumption results presented in this document can be compared. A direct comparison is not possible because the MOVES2014a model provides future VMT based upon assumed future VMT growth estimates and fuel while the fuel benefits reported in this section are not adjusted for future projected VMT. MOVES2014a-generated VMT are predictions of the future while the VMT used in analysis presented in this document is based on 2013 conditions. The table below summarizes the results of the agencies MOVES2014a analysis for various maximum set speeds.

Table 83
MOVES2014a and Phase I CAFE Baseline Results of Diesel Fuel Saved Annually

	60 mph	65 mph	68 mph
MOVES2014a Gallons of Fuel (millions)	1,005	500	131
Phase I CAFE Baseline Gallons of Fuel (millions)	863	423	188

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manufacturers would use the fuel saving credit (by installing tamper-proofing) toward CAFE compliance and it would not need the new/other technologies at the same time to meet CAFE requirements. In such a case, we expect that the total fuel savings for any set speed less than 65 mph would be the same as the fuel savings for a set speed of 65 mph. See the Alternatives chapter for the 60 mph fuel savings which can be used to fully evaluate the policy.

It should be noted that the Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles; Final Rule, 76 FR 57106 (September 15, 2011), Phase I CAFE are incorporated in the default database of the MOVES2014a model. The Phase 2 medium- and heavy-duty fuel efficiency rule has not been incorporated into MOVES2014a.

III. COSTS

The proposed rule is applicable to trucks and buses with a GVWR greater than 11,793 kg (26,000 pounds, Classes 7 and 8). There were approximately 352,200 Classes 7 & 8 vehicles sold in the U.S. in 2013.[82] Among the 352,000 heavy vehicles sold, we estimated that 46,200 were buses (with a GVWR greater than 11,793 kg (26,000 lbs.) and the remaining 305,800 were combination trucks and single unit trucks.

Table 84
Annual Sales of Vehicles with GVWR greater than 11,793 kg (26,000 lbs., Class 7 & 8)

TYPE	Total
School Bus	40,000
Cross Country/Intercity	2,200
Transit Bus	4,000
All buses	46,200
Single Unit Trucks	120,800
Combination trucks	185,000
Total heavy vehicles	352,000

<u>Vehicle modification costs:</u>

Nearly all heavy-duty engines in new vehicles are electronically controlled and are capable of being programmed to limit the maximum vehicle speed. Therefore, for the costs associated with a particular speed limiting device requirements, we assumed that all vehicles with a GVWR

[82] According to a report by Statista, Class 8 truck sales were down to 185,000 in 2013 after peaking at 195,000 in 2012. These sales totals are still much higher than in 2009, when sales did not reach 100,000 trucks. Over the five-year period, International lost market share, Freightliner and Volvo gained market share, and the others held steady.
http://www.statista.com/statistics/261483/heavy-truck-sales-in-the-united-states/
Ricardo, http://www.ricardo.com/

greater than 11,793 kg (26,000 lbs.) are equipped with an electric control unit (ECU) which is capable of being programmed to limit the maximum vehicle speed.

The agency is proposing a different approach to ensuring that the speed setting of the vehicle is not modified as compared to the UNECE requirement. We are proposing that the vehicle set speed and the speed determination parameters be readable through the on-board diagnostics (OBD) connection. In addition to showing the current settings, the agency is also proposing that the previous two setting modifications be readable and include a time and date stamp for when modifications were made. The purpose of this requirement is to assist field inspectors in determining if the vehicle has been operated with values that have been modified inappropriately. The proposed rule requires that a means must be provided for a vehicle inspector to read the last two modifications to the speed limit set (V_{set}) and the speed determination parameters as well as the time and date of the modifications. These proposed time and date stamp requirements would not result in any additional vehicle modification costs.

Although the proposed rule does not require vehicle manufacturers to offer a speed limiting device which is protected from tampering and cannot be changed by the fleet or vehicle owner, as an alternative, we estimated the costs associated with these tamper resistant speed limiting devices. In general, there are two design approaches for making an ECU tamper resistant, namely Pass Code and Hard Code.[83] The Pass Code design approach has two options. The first Pass Code option is to set speed limiting device setting at the OEM factory. With the first Pass Code option, subsequent owners would be able to legitimately change the setting if the vehicle configuration is altered and recalibration is necessary.[84] (For example, no password is needed to alter the setting.) However, speed limiting devices with the first Pass Code option would not be tamper resistant. The second option of the Pass Code design is to set the speed limiting device setting at the OEM factory and make it "factory password protected". With the second Pass Code option, vehicle owners would have to make a formal request to either the vehicle or engine manufacturers to change the setting. According to TMA, if a vehicle owner needs to make any subsequent changes, it would cost approximately $300 per vehicle with the second Pass Code option. The Hard Code design approach is to hardcode the speed limiting device set point in the ECU, based on characteristics of each vehicle produced. The Hard Code option would eliminate all possibilities of subsequent changes unless the entire ECU is replaced. With this, subsequent

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[83] Both Pass Code and Hard code are set by vehicle manufacturers. However, Hard Code would not be changed unless the entire ECU is replaced. According to TMA, subsequent ECU changes would cost owners $2,000 or more (Docket NHTSA-2007-26851-3841).

[84] TMA petition to NHTSA and FMCSA on Speed Limiting devices for Trucks, Docket: NHTSA-2007-26851-3841. In the petition, TMA proposed two options to make speed limiting devices on newly-built trucks tamper resistant. The first option is to set speed limiting device setting at the OEM factory. The costs associated with this option would be minimal since all newly-built trucks have the ability to govern speed. However, according to the petitioner, this approach would not be absolutely "tamperproof" once a vehicle is sold. The second option is to set speed limiting device setting at the OEM factory and make it "factory password protected". With the second option, vehicle owners would have to make formal request to either the vehicle or engine manufacturer to make a change in the setting. The petitioner estimated that the costs associated with the second option would be approximately $300 per vehicle to make any subsequent changes if the change is made out of sync with scheduled changes for emissions requirements.

ECU changes would cost owners $2,000 or more.[85] We assume that the less expensive TMA option would be the most likely to be adopted.

Table 85
Vehicle modification costs with Time stamping and Pass code[86]

Sales	145,502	
Type	Time-stamping	Tamper resistant
Unit Cost	$0	$300.0
Total costs	$0	$44M

Compliance test costs:

For the proposed rule, heavy vehicle manufacturers can use any appropriate methods to self-certify the performance requirements, including engineering analysis, computer simulation and track testing. We believe that manufactures would not need any tests additional to whatever they and their suppliers are currently conducting to verify the performance specifications. Therefore, the only compliance test cost associated with the proposed rule would be the agency compliance test cost.

Potential additional costs to compensate the longer travel time:

When a speed limiting device is required, it would result in a longer delivery or travel time for the same distance traveled. Throughout this analysis, to simplify matters, we will show how we calculated costs for speed limiters set to 65 mph, and primarily for combination trucks.

[85] According to Truck Manufacturers Association (TMA), "Informational Meeting with NHTSA Speed Limiting device Tamper proofing", July 9, 2007, NHTSA-2007-26851-3841, the Hard Code would cost owners $2,000 or more. With the $2,000 unit cost, the total incremental cost would be $304M.
[86] The $300 cost was based on 2007 dollars.

However, we have also considered and made identical calculations for single-unit trucks and buses and for all three vehicle types with speed limiters set to 60 mph and 68 mph. The NPRM does not propose a specific set speed requirement, but the agency would specify a maximum set speed in a final rule implementing this proposal.[87]

To estimate the delay in delivery time with a speed limiting device set at a particular speed, we utilized the relative frequency of fatalities and injuries speed zones from the 2004 – 2013 NASS General Estimates System (GES) and Fatality Analysis Reporting System (FARS) which were previously used for the fuel saving estimates.   Similar to the approach used for the fuel saving estimates, we estimated the delay in delivery time based on the national average travel speed on rural and urban interstate highways. Although the distribution of travel distance and the distribution of the travel speed would be very similar, we do not have the real world travel distance distribution data. Lacking these data we assume that the travel distance have the same distribution with respect to travel speeds, we could estimate the time delay resulting from requring speed limiting device set to a specific speed.

According to the 2013 FHWA VMT data, combination trucks traveled 87,484 million miles on rural and urban Interstates. For the 87,484 million VMT, based on the 2004 - 2013 FARS & GES data, we estimated that combination trucks with a GVWR of 26,000 and greater traveled 81,778 million miles (VMT) on rural and urban Interstates with a posted speed of 55 mph – 75

[87] Results for 60 mph and 68 mph speed limiters are reported in Appendix I.

mph. Based on the GES data, we distributed the 81,778 VMT (in millions) over five (5) posted speed limits (55 mph – 75 mph). Furthermore, under the assumption that the travel distances have the same distribution with respect to travel speeds, the combination truck VMT at each posted speed limit was distributed as shown in Table 86.

Table 86
Baseline VMT and travel speed on rural and urban interstates, combination trucks (in millions)

Travel Speed, mph	Posted Speed					Total VMT	
	55 MPH	60 MPH	65 MPH	70 MPH	75 MPH		
	20,848	11,472	20,447	18,970	10,041	81,778	Mil Hrs
45	0.0189	0.0000	0.0001	0.0000	0.0011	0.020	0.000
46	0.0718	0.0001	0.0007	0.0001	0.0035	0.076	0.002
47	0.2517	0.0007	0.0027	0.0006	0.0105	0.266	0.006
48	0.8141	0.0041	0.0105	0.0023	0.0296	0.861	0.018
49	2.4291	0.0204	0.0377	0.0082	0.0795	2.575	0.053
50	6.6869	0.0912	0.1262	0.0274	0.2034	7.135	0.143
51	16.9827	0.3657	0.3934	0.0865	0.4952	18	0.359
52	39.7921	1.3173	1.1429	0.2560	1.1468	44	0.840
53	86.0186	4.2631	3.0947	0.7121	2.5268	97	1.823
54	171.5509	12.3940	7.8094	1.8609	5.2964	199	3.684
55	315.6454	32.3720	18.3657	4.5692	10.5619	382	6.937
56	535.8109	75.9613	40.2527	10.5404	20.0378	683	12.189
57	839.1301	160.1333	82.2196	22.8442	36.1666	1,140	20.009
58	1212.4188	303.2754	156.5132	46.5159	62.1027	1,781	30.704
59	1616.1501	516.0108	277.6652	88.9879	101.4523	2,600	44.072
60	1987.5422	788.7631	459.0783	159.9433	157.6740	3,553	59.217
61	2255.0525	1083.1797	707.3705	270.0884	233.1341	4,549	74.571
62	2360.4923	1336.3513	1015.7854	428.4997	327.9434	5,469	88.211
63	2279.5765	1481.1769	1359.4144	638.7047	438.8734	6,198	98.377
64	2031.0069	1474.8892	1695.4953	894.4467	558.7621	6,655	103.978
65	1669.4532	1319.4047	1970.7712	1176.8300	676.8025	6,813	104.819
66	1266.0264	1060.3832	2134.8662	1454.7148	779.9097	6,696	101.453
67	885.7617	765.6209	2155.2615	1689.4559	855.0156	6,351	94.793
68	571.7375	496.6277	2027.7954	1843.4048	891.7663	5,831	85.755
69	340.4725	289.4104	1778.0466	1889.7286	884.8617	5,183	75.109
70	187.0566	151.5178	1452.9712	1820.0488	835.3089	4,447	63.527
71	94.8134	71.2655	1106.5365	1646.9161	750.1811	3,670	51.686
72	44.3376	30.1135	785.3610	1400.1185	640.9623	2,901	40.290
73	19.1285	11.4317	519.4787	1118.3120	521.0101	2,189	29.991

74	7.6137	3.8987	320.2293	839.2011	402.9092	1,574	21.268
75	2.7958	1.1945	183.9709	591.6624	296.4255	1,076	14.347
76	0.9472	0.3288	98.4991	391.9103	207.4776	699	9.200
77	0.2961	0.0813	49.1485	243.8958	138.1574	432	5.605
78	0.0854	0.0181	22.8551	142.6024	87.5235	253	3.245
79	0.0227	0.0036	9.9049	78.3347	52.7500	141	1.785
80	0.0056	0.0006	4.0005	40.4284	30.2460	75	0.934
81	0.0013	0.0001	1.5058	19.6030	16.4991	38	0.464
82	0.0003	0.0000	0.5282	8.9303	8.5625	18	0.220
83	0.0001	0.0000	0.1727	3.8222	4.2275	8	0.099
84	0.0000	0.0000	0.0526	1.5370	1.9857	4	0.043
85	0.0000	0.0000	0.0149	0.5807	0.8874	1	0.017
						81,777	1249.841

Table 87
VMT and travel time based on state data, with 65 mph speed limiting device

Speed, mph	55 MPH	60 MPH	65 MPH	70 MPH	75 MPH	Total VMT	Mil Hrs
	25%	14%	25%	23%	12%	100%	
45	0.0189	0.0000	0.0001	0.0000	0.0011	0.020	0.000
46	0.0718	0.0001	0.0007	0.0001	0.0035	0.076	0.002
47	0.2517	0.0007	0.0027	0.0006	0.0105	0.266	0.006
48	0.8141	0.0041	0.0105	0.0023	0.0296	0.861	0.018
49	2.4291	0.0204	0.0377	0.0082	0.0795	2.575	0.053
50	6.6869	0.0912	0.1262	0.0274	0.2034	7	0.143
51	16.9827	0.3657	0.3934	0.0865	0.4952	18	0.359
52	39.7921	1.3173	1.1429	0.2560	1.1468	44	0.840
53	86.0186	4.2631	3.0947	0.7121	2.5268	97	1.823
54	171.5509	12.3940	7.8094	1.8609	5.2964	199	3.684
55	315.6454	32.3720	18.3657	4.5692	10.5619	382	6.937
56	535.8109	75.9613	40.2527	10.5404	20.0378	683	12.189
57	839.1301	160.1333	82.2196	22.8442	36.1666	1,140	20.009
58	1212.4188	303.2754	156.5132	46.5159	62.1027	1,781	30.704
59	1616.1501	516.0108	277.6652	88.9879	101.4523	2,600	44.072
60	1987.5422	788.7631	459.0783	159.9433	157.6740	3,553	59.217
61	2255.0525	1083.1797	707.3705	270.0884	233.1341	4,549	74.571
62	2360.4923	1336.3513	1015.7854	428.4997	327.9434	5,469	88.211
63	2279.5765	1481.1769	1359.4144	638.7047	438.8734	6,198	98.377
64	2031.0069	1474.8892	1695.4953	894.4467	558.7621	6,655	103.978
65	5090.5554	4201.3012	14621.9706	16402.0379	8083.4695	48,399	744.605
						81,777	1289.796

The results in the tables above show that, for example, the time delay would be 3% when combination trucks are equipped with a 65 mph speed limiting device, assuming the overall travel distance remains the same. [(1,289.796 - 1,249.841)/1,249.841 = 3.2%]

Costs associated with the delay in delivery time:

Drivers currently employed by large trucking companies are paid by miles driven. Therefore, the delay in delivery time would not impact how much trucking company drivers can earn as they deliver cargos thru the delivery routes as long as the maximum hours of operation (required by FMCSA) is not exceeded by the delay in delivery time. However, the delay in delivery time could affect the quality of life and/or well-being of these drivers since it would reduce their free time. In addition, we expect that trucking companies would hire additional drivers to compensate for the delay in travel time. These drivers could come from a pool of current small trucking drivers who seek employment in large trucking companies and also new drivers who are not currently driving trucks. Furthermore, there could be costs due to the loss in value from slower deliveries. These cost elements are discussed separately in the following sections.

There are two cost related issues that stem from the proposed rule; transfer payments and real costs. As large trucking companies hire drivers currently employed by small business or acting as independent drivers, transfer payments would occur. Transfer payments are monetary payments from one group to another that do not affect the total resources available to society. Therefore, costs associated with transfer payments are not included in the cost estimate but are discussed throughout this section, including in the section concerning impacts on small businesses. However, there are also real costs because the use of speed limiters will result in trucks taking longer to deliver goods to their destination. This cost will either be borne directly by trucking companies who must hire new drivers (increase in operational cost) or current drivers may drive longer hours without an increase in income (lost opportunity cost). As discussed in the following section, we estimated these costs separately. Although the costs associated with the new drivers directly affect the operational cost, it would be regarded as a transfer of wealth from one group (fleets) to another (drivers). For example, if drivers have to drive longer hours to cover the same distance, there would be lost opportunity costs for the longer hours. The value of lost opportunity cost can change dramatically depending on how much of it the truck drivers have available and how to use it. The drivers would likely value the delay, such as getting home a half hour later, much more highly if the drivers are very busy or other economic opportunities are lost due to the delay. Some drivers affected by reduced speeds would lose free time devoted to recreation, household chores, or other private pursuits. Others may lose time available for pursuing secondary financial opportunities.

Currently, on average, truck drivers spend about 9 hours driving.[88] This is less than the 11 hours maximum allowed current law. According to a guidance document issued by DOT, the recommended value of travel time (VOTT) of personal intercity travel time is 70% of total earnings.[89, 90] In general, the personal intercity VOTT would be lower than the after-tax wage.

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[88] According to a report by Virginia Tech Transportation Institute (VTTI), on average commercial motor vehicle (CMV) drivers spend 66 percent of their shift driving (65.7%), 23 percent in non-driving work (22.8), and 11 percent resting (11.5%) and other activities. In the current U.S. regulations, commercial truck drivers are restricted to 11 driving hours during a 14-hour workday. Based on the VTTI study, we estimated that on average truck drivers spent 9.2 hours of their workday driving (65.7% x 14 hours = 9.2 hours). The study was sponsored by U.S. Department of Transportation, Federal Motor Carrier Safety Administration, FMCSA-RRR-11-017

[89] Revised Department Guidance on Valuation of Travel Time in Economic Analysis, July 9, 2014, available at http://www.dot.gov/sites/dot.gov/files/docs/USDOT%20VOT%20Guidance%202014.pdf.

The personal intercity VOTT established by the DOT guidance ($17.50) will be used to estimate the opportunity lost cost.

Another estimate of the value of non-work time for the current drivers is current wage plus fringe benefits which approximately represent how fleets value their drivers' time. Fringe benefits include paid leave, bonuses and overtime pay, health and other types of insurance, retirement plans, and legally required benefits (Social Security, Medicare, unemployment insurance, and workers compensation insurance). In the Electronic Logging Device (ELD) Supplementary Notice of Rulemaking (SNPRM) Regulatory Impact Analysis (RIA), FMCSA assumes that drivers value their leisure time at the same amount that they accept in exchange for it, that is their base wage plus fringe benefits.[91] FMCSA estimates that fringe benefits are equal to 55 percent of wages. Based on the SNPRM, we assume another value of non-work time would be equal to the current wage plus 55 percent of the wage. (Data from Bureau of Labor Statistics indicate that hourly wages for truck drivers in 2013 were $20.08, adjusting for fringe benefits

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[90] The opportunity cost is the loss of potential gain from other alternatives when one alternative is chosen. In other words, the opportunity cost of a choice is the value of the best alternative forgone. In reality, a small percentage of drivers would go home (or, in the case of long haul, retire to the sleeper berth) a little later with the speed limiters rule. The opportunity cost is the "cost" incurred by not enjoying the benefit (i.e., going home little sooner, in this case) that would be had by taking the second best choice available (i.e., driving little longer).

[91] In the SNPRM, FMCSA states that BLS does not publish data on fringe benefits for specific occupations, but it does for the broad industry groups in its Employer Costs for Employee Compensation (ECEC) release. This RIA uses an average hourly wage of $22.03 and average hourly benefits of $12.04 for private industry workers in "transportation and warehousing" to estimate that fringe benefits are equal to 55 percent ($12.04 ÷ $22.03) of wages. For overhead, the Agency used industry data gathered for the Truck Costing Model developed by the Upper Great Plains Transportation Institute, North Dakota State University.[3] Research conducted for this model found an average cost of $0.107 per mile of CMV operation for management and overhead, and $0.39 per mile for labor, indicating an overhead rate of 27 percent ($0.107 ÷ $0.39).

based on the FMCSA SNPRM (55%) brings the wage to \$31.12, \$20.08 hourly wage x 1.55 = \$31.12).[92]

In addition to the lost opportunity cost, we estimated costs associated with the loss in value resulting from slower deliveries. According to FHWA, the hourly inventory costs for the payload values of combination trucks and single unit trucks are \$0.33 and \$0.19 in 2013 dollars, respectively. [93] These values were developed by FHWA as described in HERS-ST Technical Report.[94] To compute the inventory costs, an hourly discount rate was computed and multiplied by the value of a composite average shipment. The discount rate use is equal to the average prime bank lending rate plus one percent. Dividing this rate by the number of hours in a year produces an hourly discount rate is 0.000485 percent. The average payload of SUTs and combinations trucks used by FHWEA in their study was 25,000 lb. and 42,000 lb. respectively. The average value of commodities shipped by truck was estimated to be \$1.52 per pound (on a ton-mile weighted basis). That value is then multiplied by the hourly discount rate of 0.000485 to produce an hourly value of freight inventory for 2010 equal to \$7.37E-06/lb./hr. This value is then multiplied by the average payload to produce an hourly inventory cost of \$0.31 for combinations trucks and \$0.18 for SUTs. NHTSA and FMCSA then adjusted these 2010 values to 2013 dollars to produce the hourly inventory cost for payloads of \$0.33 and \$0.19 for

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[92]http://www.bls.gov/oes/current/oes533032.htm The 2015 wage was adjusted to 2013 dollars.
[93] http://ops fhwa.dot.gov/wz/resources/publications/fhwahop12005/sec2 htm
The hourly inventory costs for the payload values of combination trucks and single unit trucks are \$0.31 and \$0.18 in 2010 dollars, respectively. The values are adjusted to 2013 dollars.
[94] http://www.fhwa.dot.gov/asset/hersst/pubs/tech/tech05.cfm#sect555

combination trucks and SUTs respectively. The agencies seek comment on the appropriateness of adjusting annual discount rates for very short delays measured in minutes or hours.

As discussed previously, there are two cost related issues stem from the proposed rule, transfer payments and real costs. For real costs, when deliveries take additional time, time that could be spent doing other activities is devoted to truck driving. For the purpose of this analysis, we assume that those activities consist of leisure time for truck drivers.

Societal costs:

We estimate the societal cost of delay in deliveries mainly based upon the opportunity cost of the drivers who must work additional hours to deliver the same amount of goods. For this analysis, the primary estimate of opportunity cost is based upon the DOT guidance ($17.50 in 2013 dollars). As discussed in the "delay in delivery" section, we estimated a total of 46 million hours of delay in delivery time with 65 mph speed limiters. In addition, we considered inventory costs as part of the societal costs. Accordingly, the societal costs were estimated to be $457 million for combination trucks, $53 million for SUTs and $13 million for buses discounted at 7% in 2013 dollars.

Table 88
Opportunity costs associated with 65 mph speed limiter, in millions, in 2013 dollars

Vehicle	Hours, in M's	Societal cost/hr	Not discounted	3%	7%
Combination truck	40	17.50	$699	$566	$449
SUT	5	17.50	$82	$66	$52
Bus	1	17.50	$20	$16	$13
Total	46	17.50	$801	$648	$514

Table 89
Inventory costs associated with 65 mph speed limiter, in millions, in 2013 dollars

Vehicle	Not discounted	3%	7%

Combination truck	$13.2	$10.7	$8.5
SUT	$1.1	$0.9	$0.7
Bus	$0	$0	$0
Total	$14.3	$11.6	$9.2

Table 90
Societal costs associated with 65 mph speed limiter, in millions, in 2013 dollars*

Vehicle	Not discounted	3%	7%
Combination truck	$712	$577	$457
SUT	$83	$67	$53
Bus	$20	$16	$13
Total	$815	$659	$524

* The numbers were rounded to the nearest integer.

Fleet costs:

Due to their relatively large amount of resources, such as contingent drivers and trucks, large trucking companies would have several ways to deal with the proposed speed limiter rule. We examined two scenarios for the cost estimate.

Scenario 1:

First, drivers employed by large trucking companies drive longer hours but keep the same miles traveled. There would be lost opportunity costs for drivers who must spend more hours in order to make the same wage. As we more closely examine drivers employed by large trucking companies, the drivers could be separated into three groups based on current hours of service (HOS); Group 1 consists of drivers currently well below the maximum HOS restrictions; Group 2 consists of drivers who are somewhat below HOS maximum restrictions; and Group 3 consists of drivers currently at or very close to the HOS maximum. In Scenario 1, there would be lost opportunity costs in drivers in Group 1 and 2 since they would drive longer hours without exceeding the maximum HOS. The opportunity costs associated with these drivers would be different since some drivers would drive longer hours than others. In addition, some drivers in Group 2 and drivers in Group 3 would exceed the maximum HOS with a speed limiter. To compensate for the delay, trucking companies would hire additional drivers. Although it is desirable to analyze separately impacts on drivers in each group, due to limited data, we are unable to separate the opportunity cost for each Group.[95]

The next issue, as we discussed briefly in the previous section, is whether to value lost opportunity cost at wage rate or at a lower rate representing the value of leisure time. On average truck drivers spend about 9 hours driving and additional 2 hours for loading, unloading and other shipping related activities. With the 11 hours driving limit, most drivers would have flexibility to work more hours to make up their lost wages. Therefore, in practice, we believe that more drivers would give up non-market work and leisure activities to compensate the longer driving hours. DOT recommends that travel time for private activities be valued at 50-70% of wage rate (50% for personal local travel and 70% for personal intercity travel). We believe that the personal intercity VOTT may be the closest proxy for the value of leisure time since most trucks affected by the speed limiter rule would be operational on interstate and interstate-like highways (i.e., principal arterial interstate, other freeways or expressways in the FARS crash data). The time that is taken from workers in order to maintain their current income would have

[95] In some cases, we expect that the amount of team driving would increase as trucking companies utilize team driving. In other cases, trucking companies would make operational changes to reroute their deliveries without using additional team driving. In any case, we believe that it is feasible to meet the requirements with team driving which would be least costly method of compliance.

otherwise been leisure time. Therefore, we believe that the time should be valued at less than the full wage.

By contrast, one could argue that the drivers are implicitly valuing this time at the wage rate since they are choosing to drive the extra hours. But, they are only doing that in light of the wage reduction resulting from the rule. At their current income, some of them chose leisure over wages. There may be some sort of threshold valuation phenomena involved here. Assuming their hours of service are voluntarily less than eleven, above a certain wage level they value their leisure time more than the added wages, but below it they value the added wages more than their leisure time. But this implies that the added leisure time that they are giving up is worth more to them than their wages, so long as they can make at least the threshold wage level – the opposite of what is implied by DOT travel time guidance.

The diagram below illustrates this scenario (i.e., Scenario 1), including both the real costs discussed above and transfer costs. The dot line represents the transfer costs that occur when large businesses hire drivers currently employed by small business or acting as independent drivers.

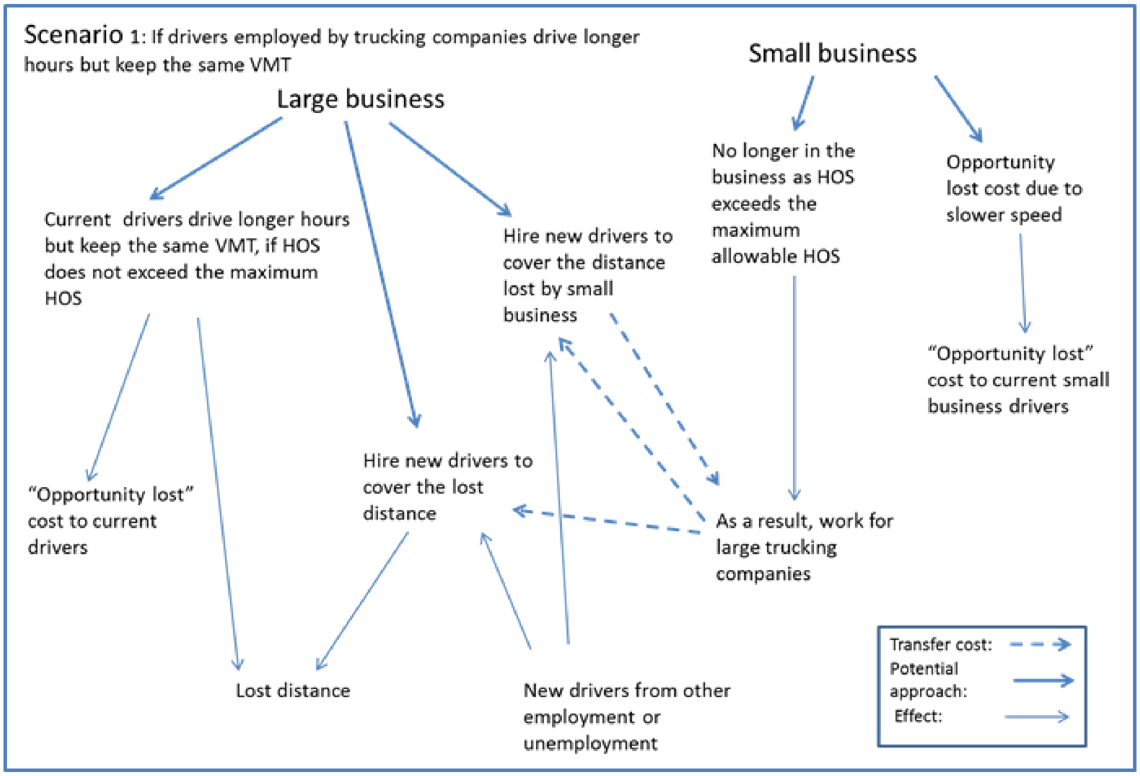

Figure 20. Scenario 1, if drivers employed by trucking companies drive longer hours but keep the same VMT

<u>Scenario 2:</u>

In the second scenario, drivers employed by large trucking & bus companies are paid the same amount/income for the fewer miles driven with the same amount of driving hours. Trucking companies hire new drivers to make up the difference in delivery capability. Potential costs would be incurred when trucking companies hire new drivers to move the shortfall in goods shipped. This could impact shipping rates if shippers pass on these higher costs to customers. However, improved fuel economy from speed limiters would reduce operating costs. The net impact of these offsetting impacts on shipping rates is unclear, as discussed in the Secondary Impacts section below. Although it is difficult to estimate the cost of new drivers, for this analysis, we have used the wage trucking companies are paying for the current drivers (i.e., wages plus fringe benefits).

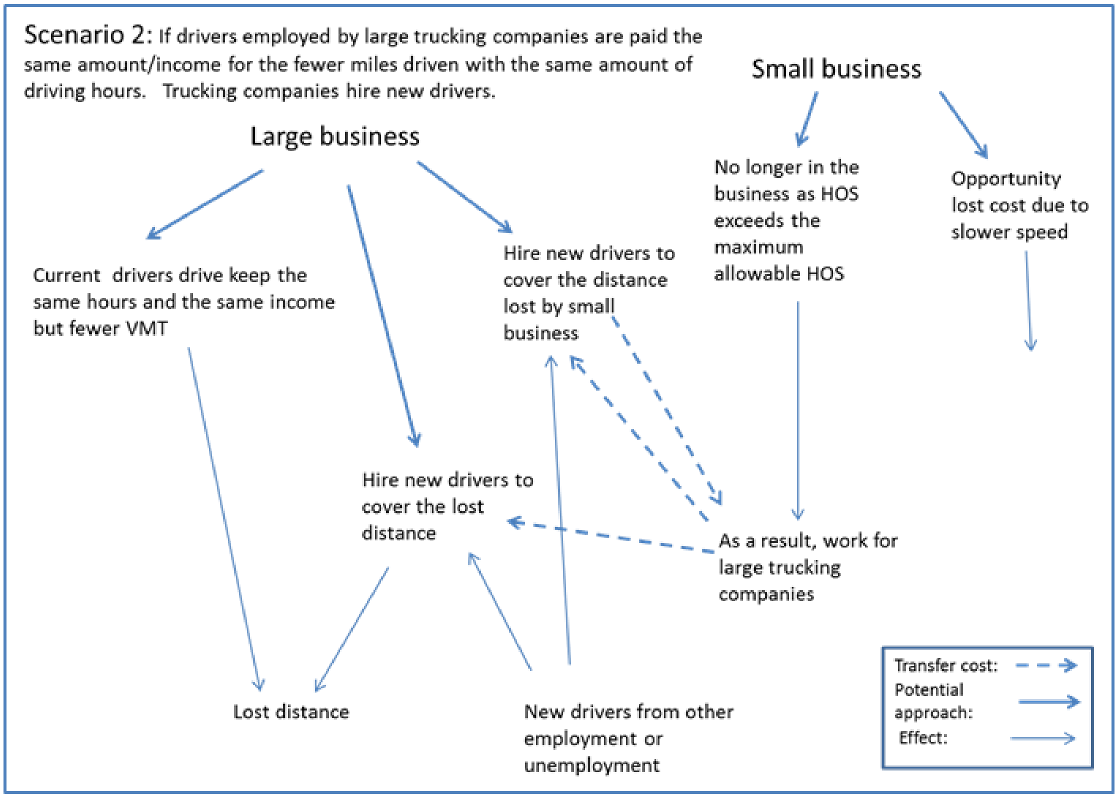

Figure 21. If driver employed by large trucking companies are paid the same amount/income for the fewer miles driven with the same amount of driving hours.

Table 91
Impacts on trucking companies, drivers and consumers by Scenario

Scenario	Large trucking companies	Drivers	
		In large	In small
Drivers employed by large trucking companies drive longer hours but keep the same miles traveled. Some of trucking companies hire new drivers.	Costs to hire new drivers. Increase in operational cost	Opportunity lost cost	Opportunity lost cost
Drivers employed by large trucking & bus companies are paid the same amount/income for the fewer miles driven with the same amount of driving hours. Trucking companies hire new drivers.	Costs to hire new drivers. Increase in operational cost	No change	Opportunity lost cost

<u>Delivery Times:</u>

One concern of decreasing travel speed is that certain deliveries that come close to the maximum hours of service may no longer be doable within one day. The maximum allowable amount of hours of service is put in place by FMCS. It limits how many hours a commercial driver can spend driving in a day or a week. If a delivery could not be completed within that day's hours of service due to the lower top speed put in place by the limiting device, then the driver would have to stop driving.

The agencies have limited data on hours of service (HOS) to estimate the delay in delivery time with the proposed 65 mph speed limiting device. (Various industry firms are currently collecting information on driver e-logging data, but there are no final or full studies that have been completed yet.) According to a report by Virginia Tech Transportation Institute (VTTI),[96] on average commercial motor vehicle (CMV) drivers spend 66 percent of their shift driving (65.7%), 23 percent in non-driving work (22.8), and 11 percent resting (11.5%) and other activities.

We note that the VTTI study was not an attempt to characterize work and rest patterns in the motor carrier industry. Its purpose was to examine "the relationship between safety-critical events and driving hours, work hours, and breaks." There were a relatively small number of drivers (97) in the study, none of whom drove buses or made local deliveries. Although those 97 drivers were not intended to be a representative sample of driving patterns in the entire motor carrier industry, due to limited data and relatively high costs associated with HOS studies, the

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[96] The study was sponsored by U.S. Department of Transportation, Federal Motor Carrier Safety Administration, FMCSA-RRR-11-017. http://www.fmcsa.dot.gov/facts-research/research-technology/report/work-hours-hos.pdf
http://www.ooida.com/Issues&Actions/Regulatory/issues/HOS/Docs/Work-Hours-HOS%5B1%5D.pdf

time-in-transit analysis was made based on the driving hours recorded in the study. The agencies request comments on the HOS for commercial vehicles.

In the current U.S. regulations, commercial truck drivers are restricted to 11 driving hours during a 14-hour workday. Therefore, based on the VTTI study, we estimated that on average the drivers spent 9.2 hours of their workday driving (65.7% x 14 hours = 9.2 hours). If we assume that 50% of the total driving hours are less than 9.2 hours and the remaining 50% are more than 9.2 hours and that the required 11 driving hours is the maximum, the driving hours would range from 7.4 hours to 11 hours [(11 max hrs. - 9.2 average hrs. = 1.8 hrs. 9.2 hrs. – 1.8 hrs. = 7.4 minimum driving hours]. In other words, 50% of drivers would spend 9.2 hours or greater in driving but not more than 11 hours.

As discussed previously, for example, we estimated that on average a 65 mph speed limiting device would increase delivery time by 3% (3.2%) for combination trucks. For the estimated 3% delay in delivery time, CMV drivers who currently drive more than 10.65 hours would not be able to deliver the same amount of payload within the required 11 driving hours [11/(1+0.032) = 10.65 hrs., rounded].

For the calculation, we used a triangular distribution as a proxy for the hours of service. Based on the 9.2 average driving hours, 7.4 minimum driving hours, 11 maximum driving hours and 10.65 “cut-off” driving hours with a 65 mph speed limiter, we estimated that approximately 2% of CMV drivers would not be able to deliver the same amount of payload within the maximum

11 driving hours.[97] (The CMV distribution in Figure 22 shows that the area greater than 10.65 hours is 2% (1.8%) of the total area.[98])

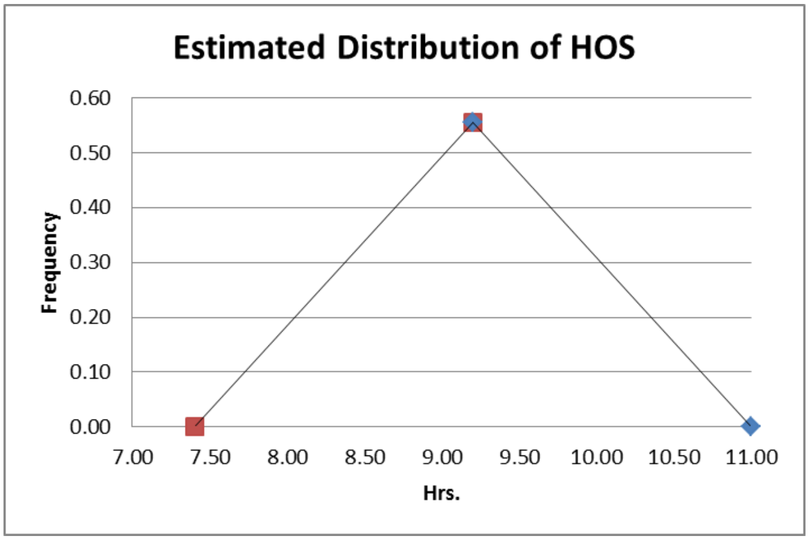

Figure 22. Estimated distribution of CMV driving hours

The costs associated with different types of heavy vehicles are discussed below:

<u>Combination trucks:</u>

The adjusted combination truck VMT shows that combination trucks have a total of 81,778 million VMT annually. For the 81,778 million VMT, as discussed in the impacts on small business section, 70% or 57,244 million miles would be from large trucking companies. For the estimate, we assumed that the 57,244 million VMT have the same distribution that was used in

[97] Although it would be reasonable to assume that the driver hours would be distributed according to the Normal distribution, the report does not provide the standard deviation. For the percentage of drivers who are currently driving more than 10.65 hours, we assumed that the percentage would linearly increase from 7.4 hrs to 9.2 hours and also linearly decrease from 9.2 hours to 11 hour. For the analysis, therefore, we used a linear approximation to estimate the percent of drivers who would exceed the maximum HOS.

[98] Area = (1/2) x (height) x (base); height = -0.31xhours + 3.40. Area = (1/2)x(0.11)x(0.34); Area = 1.8%, rounded

the time delay analysis. The overall total delay in delivery time for combination trucks with a 65 mph speed limiter would be 40 million hours when compared to the current baseline. (See the benefit chapter for additional discussion on delay in delivery time.)

Under Scenario 1, large trucking companies would hire additional drivers to cover miles that would not be covered when a speed limiter is used, as some drivers would exceed the maximum HOS.[99] The percent of drivers who would exceed the maximum HOS was estimated to be 2% (1.8%) with 65 mph speed limiters. Therefore, we estimate that driving hours need be covered by new drivers would be 0.5 million hours (40 million hours x 70% = 28 million hours, 28 million hours x 2% = 0.5 million hours, rounded), as some drivers would exceed the maximum hours of service (HOS). We note that the costs associated with the new drivers would be regarded as a transfer of wealth from one group (fleets) to another (drivers).

For the lost opportunity cost, as discussed previously, the hourly cost would be $17.50 in 2013 dollars. The lost opportunity cost for combination truck drivers currently employed by large trucking companies was estimated to be $309 million with 65 mph speed limiters, discounted at 7%, $481 million with no-discount (28 million hours – 0.5 million hours = 27.5 million hours, 27.5 million hours x $17.50 = $481M, $309 at 7% and $389 at 3%).

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[99] We note that trucks with a speed limiter set at 65 mph or below would not be affected by the proposed rule. As discussed in the benefit chapter, we considered overall impacts of requiring a speed limiter based on the overall VMT and the overall average travel speed on a particular posted road. If trucks with a 65 mph speed limiter are excluded from the calculation, for example, the overall VMT considered would decrease whereas the overall average travel speed would increase.

In addition, for example, with 65 mph speed limiters, the inventory cost was estimated to be $6 million discounted at 7% (28 million hours of delay in delivery time x $0.33 inventory cost/hr = $9.23M, $6M at 7% and $7M at 3%)

The cost parameters for large combination trucking companies and drivers currently employed by large combination trucking companies in Scenario 1 are shown below.

Table 92
Parameters used in Scenario 1, large combination truck companies with 65 mph speed limiter (millions)

<table>
<tr><td colspan="2">Total VMT, adjusted</td><td>81,778</td></tr>
<tr><td colspan="2">VMT by large trucking companies</td><td>57,244</td></tr>
<tr><td colspan="2">Delay in delivery hours at 65 mph</td><td>28</td></tr>
<tr><td colspan="2">Driving hours need be covered by new drivers</td><td>0.5</td></tr>
<tr><td colspan="2">Driver hourly wage, estimated, ($20.08 average wage + fringe benefits)</td><td>$31.12</td></tr>
<tr><td rowspan="2">Transfer cost</td><td>Cost to large trucking companies to hire new drivers for the delay in delivery time</td><td>$16</td></tr>
<tr><td>Cost to large trucking companies to hire new drivers for the delay in delivery time @7%</td><td>$10</td></tr>
<tr><td rowspan="4">Opportunity cost</td><td>Current driver lost opportunity cost, in millions</td><td>$481</td></tr>
<tr><td>Current driver lost opportunity cost, in millions, @7%</td><td>$309</td></tr>
<tr><td>New driver lost opportunity cost, in millions</td><td>$8.77</td></tr>
<tr><td>New driver lost opportunity cost, in millions, @7%</td><td>$5.64</td></tr>
<tr><td colspan="2">Inventory cost, @7%</td><td>$6</td></tr>
</table>

Under Scenario 1, large trucking companies can hire additional drivers to compensate miles that would not be cover when a speed limiter is used. However, unlike large trucking companies, small trucking companies and owner-operators would not be able to hire new drivers due to limited resources. The difference in wages would be considered transfer costs and as such are not included in the cost estimate.

For the remaining drivers employed in small trucking companies and owner-operators, the drivers would drive longer hours to cover the same miles when a speed limiter is required. As a result, there would be lost opportunity cost for drivers who must spend more hours in order to make the same income as they are paid by miles driven.

With a 65 mph speed limiter, for example, the total delay in delivery time would be 12 million hours for small trucking companies and owner-operators (1,289.796 million hrs. with a 65 mph speed limiter – 1,249.841 million hours with the baseline = 40 million hours (39.95 million hours. 39.95 million hours x 30% VMT by small trucking company = 12 million hours). Similar to large trucking companies, we estimate that 2% of current drivers would exceed the maximum HOS with the estimated delay in delivery time of 3% (For the calculation used, see the similar calculation used for large trucking companies). Under the assumption that small trucking companies and owner-operators would not be able to hire new driver due to limited resources, we estimate that 0.2 million hours need to be covered with new drivers hired by large trucking companies (40 million hours x 30% = 12 million hours, 12 million hours x 2% = 0.2 million hours, rounded). In other words, we expect that large trucking companies would hire additional drivers to cover the distance that is not covered by small trucking companies and owner-operator when a 65 mph speed limiter is used.

For the lost opportunity cost in small and owner-operator trucking businesses, the hourly cost of $17.50 was used, based on the personal intercity travel VOTT. The total lost opportunity cost was estimated to be $132 million with 65 mph speed limiters, discounted at 7% ($305 at 3%) for the upper range delay in delivery time (12 million hours – 0.2 million hours = 10 million hours, 10 million hours x $17.50 = $206M, $132M at 7% and $167M at 3%, rounded).

Table 93
Parameters used in Scenario 1, small and owner-operator combination truck companies, with 65 mph speed limiters

VMT by small & owner-operator trucking companies, in millions	24,533

Delay in delivery hours from current speed to 65 mph, in millions		12
Driving hours that need to be covered by new drivers, in millions		0.2
Driver hourly wages, estimated		$31.75
Transfer cost	Cost to LARGE trucking companies to hire new drivers, in millions	$7
	Cost to LARGE trucking companies to hire new driver @7%, in millions	$4
Opportunity cost	Lost opportunity cost, drivers employed, in millions	$206
	Lost opportunity cost, in M's, @7%	$132
	New driver lost opportunity cost, in millions	$3.76
	New driver lost opportunity cost, in millions, @7%	$2.42
Inventory cost @7%		$3

Under Scenario 1, the estimated costs from small and owner-operator companies are combined with the estimated costs from large trucking companies to derive the net cost. When the transfer costs and the lost opportunity costs were combined, it resulted in $471 million discounted at 7% in 2013 dollars, when 65 mph speed limiters are used. Since the costs associated with the new drivers would be a transfer of wealth from one group (fleets) to another (drivers), the societal cost would be $449 million discounted at 7% in 2013 dollars (A total time delay of 39.95 million hours x $17.50 VOTT = $699, $449 at 7%. Alternatively, $441M lost opportunity cost of current drivers + $8M lost opportunity cost of new drives = $449M at 7%)).

Table 94
Under Scenario 1, Overall cost for combination trucks,* in millions, in 2013 dollars, if small trucking companies **can** hire new drivers, with 65 mph speed limiters

Scenario 1, CT	Not discounted			discounted at 3%			discounted at 7%		
Large & Small companies	Large	Small	total	Large	Small	total	Large	Small	total
(Lost opportunity cost, current drivers)	$480.68	$206.00	$686.68	$389.10	$166.76	$555.85	$309	$132	$441
(Lost opportunity cost, new drivers)	$8.78	$3.77	$12.54	$7.10	$3.05	$10.15	$5.64	$2.42	$8
(Cost to hire new drivers)	$15.66	$6.71	$22.37	$12.68	$5.43	$18.11	$10	$4	$14
(Inventory cost)	$9.22	$3.96	$13.18	$7	$3.20	$10.67	$6	$3	$8
Total			$722.23			$584.63			$471
Total lost opportunity cost, at 7%						$566			$449
Total Societal Cost, at 7%						$577			$457
Total Fleet cost without inventory cost, at 7%						$18			$14

Total Fleet cost with inventory cost, at 7%	$29		$22

* The numbers are rounded to the nearest integer.

Table 95
Under Scenario 1, Overall cost for combination trucks,* in millions, in 2013 dollars, if small trucking companies **cannot** hire new drivers, with 65 mph speed limiters

Scenario 1, CT	Not discounted			discounted at 3%			discounted at 7%		
Large & Small companies	Large	Small	total	Large	Small	total	Large	Small	total
(Lost opportunity cost, current drivers)	$480.68	$206.00	$686.68	$389.10	$166.76	$555.85	$309	$132	$441
(Lost opportunity cost, new drivers)	$8.78	$3.77	$12.54	$7.10	$3.05	$10.15	$5.64	$2.42	$8
(Cost to hire new drivers)	$22.37	**$0**	$22.37	$18.11	**$0**	$18.11	$14	**$0**	$14
(Inventory cost)	$9.22	$3.96	$13.18	$7	$3.20	$10.67	$6	$3	$8
Total			$722.23			$584.63			$471
Total lost opportunity cost						$566			$449
Total Societal Cost						$577			$457
Total Fleet cost without inventory cost, at 7%						$18			$14
Total Fleet cost with inventory cost, at 7%						$29			$22

* The numbers are rounded to the nearest integer.

Table 96
Fleet costs with 65 mph speed limiter, combination trucks, Scenario 1, in millions, in 2013 dollars, if small trucking companies **cannot** hire new drivers, ($20.08 average + fringe benefits = $31.75)

Scenario 1, CT	Not discounted			discounted at 3%			discounted at 7%		
Large & Small companies	Large	Small	total	Large	Small	total	Large	Small	total
(Cost to hire new drivers)	$22.37	**$0**	$22.37	$18.11	**$0**	$18.11	$14	**$0**	$14
Inventory Cost			$13.18			$10.67			$8
Total Fleet Cost			$22.37			$18.11			$22

Under Scenario 2 for combination trucks, drivers employed by large trucking companies are paid the same amount/income for the fewer miles drivers with the same amount of driving hours. Therefore, impacts on current drivers employed by large trucking companies would be insignificant. Under Scenario 2, the total combined transfer and opportunity cost was estimated to be $1,021 million discounted at 7 percent in 2013 dollars, when 65 mph speed limiters are used. Among the $1.021 million combined cost, $564 million is for the new drivers with the

$31.25 hourly wage plus fringe benefits. Although trucking companies would need to spend $564 million to hire new drivers to cover the delay in delivery time, this cost is treated as transfer cost. As previously discussed in the Scenario 1, the societal cost was estimated to be $449 million discounted at 7 percent.

Table 97
Parameters used in Scenario 2, large combination truck companies with 65 mph speed limiter

Delay in delivery hours a with 65 mph speed limiter, in millions	28
Driver hourly wage plus fringe benefits, estimated	$31.25
Cost to hire new drivers to compensate the delay in delivery time, in millions	$871
Cost to hire new drivers to compensate the delay in delivery time @7%, in millions	$560

Table 98
Under Scenario 2, overall cost for combination trucks, in millions, $2013
if small trucking companies **can** hire new drivers, with 65 mph speed limiters

Scenario 2, CT	Not discounted			discounted at 3%			discounted at 7%		
Large & Small companies	Large	Small	total	Large	Small	total	Large	Small	total
(Lost opportunity cost, current drivers)	$0	$206.00	$206.00	$0	$166.76	$166.76	$0	$132	$132
(Lost opportunity cost, new drivers)	$0	$493.23	$493.23	$0	$399.26	$399.26	$0	$317	$317
(Cost to hire new drivers)	$870.49	$6.68	$877.18	$704.64	$5.41	$710.05	$559.46	$4.30	$564
(Inventory cost)	$9.23	$3.96	$13.19	$7	$3.20	$10.67	$6	$3	$8
Total			$1,096.37			$887.48			$1,021
Total lost opportunity cost									$449
Total Societal Cost									$457
Total Fleet cost without inventory cost, at 7%									$564
Total Fleet cost with inventory cost, at 7%									$572

Table 99
Under Scenario 2, overall cost for combination trucks, in millions, $2013
if small trucking companies **cannot** hire new drivers, with 65 mph speed limiters

Scenario 2, CT	Not discounted			discounted at 3%			discounted at 7%		
Large & Small companies	Large	Small	total	Large	Small	total	Large	Small	total
(Lost opportunity cost, current drivers)	$0	$206.00	$206.00	$0	$166.76	$166.76	$0	$132	$132
(Lost opportunity cost, new drivers)	$0	$493.23	$493.23	$0	$399.26	$399.26	$0	$317	$317
(Cost to hire new drivers)	$877.18	**$0**	$877.18	$710.05	**$0**	$710.05	$563.76	**$0**	$564
(Inventory cost)	$9.23	$3.96	$13.19	$7	$3.20	$10.67	$6	$3	$8

Total	$428.67			$347.00			$1,021
Total lost opportunity cost							$449
Total Societal Cost							$457
Total Fleet cost without inventory cost, at 7%							$564
Total Fleet cost with inventory cost, at 7%							$572

Table 100
Fleet costs with 65 mph speed limiter, combination trucks, Scenario 2, in millions, in 2013 dollars, if small trucking companies **cannot** hire new drivers, (($20.08 average + fringe benefits = $31.75)

Scenario 2, CT	Not discounted			discounted at 3%			discounted at 7%		
Large & Small companies	Large	Small	total	Large	Small	total	Large	Small	total
(Cost to hire new drivers)	$877.18	**$0**	$877.18	$710.05	**$0**	$710.05	$563.76	**$0**	$564
(Inventory cost)	$9.23	$3.96	$13.19	$7	$3.20	$10.67	$6	$3	$8
Total Fleet Cost			$890			$721			$572

For the scenarios examined, we believe Scenario 1 is the most likely scenario starting out as it represents the current business model. Under Scenario 2, drivers employed by large trucking companies are paid the same amount/income for the fewer miles driven with the same amount of driving hours. Therefore, impacts on current drivers employed by large trucking companies would be insignificant. Trucking companies would need to hire new drivers to move the shortfall in goods shipped, but costs associated with hiring new driver would be offset by fuel savings based on current average wages. However, because this represents a change in the current business model, we believe Scenario 2 is less likely when compared to Scenario 1. However, it is possible that the demand for more drivers would lead to increased pay for better drivers and that over time Scenario 2 could be the new market business model. Scenarios 1 and 2 represent a potential range of actions that market could undertake in response to this proposed rule.

In summary, for example, when the costs associated with a 65 mph speed limiting device were estimated, it resulted in a total of $449M lost opportunity cost discounted at 7% without the inventory cost. With the inventory cost, the cost was estimated to be $457M at 7% in 2013 dollars with 65 mph speed limiters.

We note that the societal cost ($457M) for combination trucks with 65 mph speed limiters would be offset by the expected fuel savings. However, in some cases the fleet fuel savings are smaller than the increase in operational cost. For example, under Scenario 2, combination truck companies would save $716 million in fuel (based on the after-tax gasoline price of $3.663 per gallon). However, at higher wages, the increase in operational cost would exceed the fuel savings.

Table 101
Hourly wage vs operational costs for trucking companies, in millions[100]

Percentile:	50% (Median)	75%	90%
Hourly Wage:	$19.36	$24.13	$29.81
Increase in operational cost, in M's:	$548	$686	$845
Fuel saving, after-tax, in M's:	$716	$716	$716
Net saving for fleet, in M's:	$168	$30	-$129

In other words, when trucking companies hire high wage drivers, the operational cost could increase even with the expected fuel savings.

[100] BLS http://www.bls.gov/oes/current/oes533032.htm

For SUTs and Buses, similar to the approach used for combination trucks, we examined the two different scenarios. The results are summarized in Table 102, Table 103, and Table 104.

Table 102
Fleet costs with 65 mph speed limiter, SUTs, Scenario 1, in millions, in 2013 dollars, if small trucking companies **cannot** hire new drivers

Scenario 1, SUT	Not discounted			discounted at 3%			discounted at 7%		
Large & Small companies	Large	Small	total	Large	Small	total	Large	Small	total
(Cost to hire new drivers)	$2.6	**$0**	$2.6	$2.1	**$0**	$2.10	$1.7	**$0**	$1.7
(Inventory cost)	$0.62	$0.46	$1.08	$0.5	$0.37	$0.87	$0.4	$0.3	$0.7
Total Fleet Cost			$3			$3			$2

Table 103
Fleet costs with 65 mph speed limiter, SUTs, Scenario 2, in millions, in 2013 dollars, if small trucking companies **cannot** hire new drivers

Scenario 2, SUT	Not discounted			discounted at 3%			discounted at 7%		
Large & Small companies	Large	Small	total	Large	Small	total	Large	Small	Total
(Cost to hire new drivers)	$102.1	**$0**	$102.1	$82.7	**$0**	$82.7	$65.6	**$0**	$65.6
(Inventory cost)	$0.62	$0.46	$1.08	$0.5	$0.37	$0.87	$0.4	$0.3	$0.7
Total Fleet Cost			$103			$84			$67

Table 104
Fleet costs with 65 mph speed limiter, buses, Scenarios 1 & 2, in millions, in 2013 dollars, if small trucking companies **cannot** hire new drivers

Buses	Not discounted			discounted at 3%			discounted at 7%		
Large & Small companies	Large	Small	total	Large	Small	Total	Large	Small	total
(Cost to hire new drivers)	$0	$0.59	$0.59	$0	$0.48	$0.48	$0	$0.38	$0.38
Total Fleet Cost			$			$			$0.38

The overall (societal) costs associated with a 65 mph speed limiter are summarized below.

Table 105
With 65 mph speed limiter, societal and inventory costs associated with the delay in delivery time, in millions, 2013 dollars*

Cost	CT		SUT		Bus		Total	
	3%	7%	3%	7%	3%	7%	3%	7%
Opportunity cost	$566.0	$449.4	$66.0	$52.4	$15.9	$12.6	$647.8	$514.4
Inventory cost	$10.7	$8.5	$0.9	$0.7	$0	$0	$11.6	$9.2
Total Societal cost	$576.7	$457.9	$66.9	$53.1	$15.9	$12.6	$659.4	$523.6

* Numbers were rounded to the nearest integer.

Secondary Impacts:

Our estimate of the costs and benefits of this proposal indicates that limiting vehicles to a particular speed will likely result in a decrease in cost to the trucking industry. This could potentially result in secondary impacts that are difficult to quantify because the response of manufacturers and drivers is difficult to predict. The principle impact that might occur is a change in vehicle use in response to shifts in the cost of driving. This is commonly referred to as the rebound effect. If trucking companies save money through the use of speed limiters, they may pass on some or all of the savings to consumers. This, in turn, could increase the demand for their services, which would increase the VMT of the truck fleet. This added driving would increase fuel consumption, which would in turn increase greenhouse gases and offset a portion of the savings in fuel and pollutants that results from speed limiters.

However, the actual impact is uncertain. For heavy vehicles, the rebound effect could manifest in two ways. First, by making transporting goods by truck marginally cheaper, some goods that are currently transported by other modes of transportation such as rail could be transported by truck. This would increase fuel consumption in the trucking industry but potentially decrease it in other industries. Second, the reduction in costs in the trucking industry could be passed on to manufacturers, who in turn will pass the savings onto consumers by lowering the prices of goods. At lower prices, consumers will demand additional goods which will require additional trucking loads to be shipped. Either of these shifts will result in an increase in load size or VMT and reduce the fuel and GHG savings and potentially decrease the safety benefits of the rule. Alternately, it is also possible that the delay in transporting goods caused by mandatory speed limiters could cause some goods currently transported by truck to be transported by a faster mode of transportation such as air. There are thus a number of possible outcomes which could occur in response to this rule and positive rebound effects that result from shifts in transportation modes to one industry can be offset by negative rebound effects on shifts away from other industries.

Another unquantified effect that could impact the cost savings projected by this proposal is the potential for increase in truck driver pay. Our estimate is that 4,000 additional drivers would need to be hired if the agencies required speed limiters to be set to 65 mph, for example. It is possible that an increase in demand for drivers could cause the wage rates for all drivers to be increased. The increased wages would be paid to drivers with the cost savings that fleets would realize through lower fuel costs. Under this scenario, consumer prices impacts would be decreased and rebound effects may become negligible or non-existent.

It is unclear how these various conflicting industry and labor market forces will respond in the marketplace. We believe it is possible that some combination of these impacts will occur if this proposal is adopted. We do not have the data to estimate the relative magnitude of each secondary effect. For example, if driver wages rise higher, we would expect the impact on demand for trucking services to be relatively small. However, if driver pay does not rise, we would expect the rebound effect to be more significant. Although we do not have sufficient information to quantify secondary effects, we believe it possible that some of the cost savings will be lost to these secondary effects. The Agency seeks comment on secondary effects from speed limiters.

Impacts on Small Business:

The agencies believe that the proposed rule may have a significant economic impact on a substantial number of small businesses. For a speed limiting device set at a particular speed, there are many factors to be considered for the overall income of small trucking and bus companies. Two important factors, namely delay in delivery time and competitiveness are discussed below.

Delivery time:

In particular, the delay in delivery time would potentially costly to owner-operators. As FMCSA has pointed out in previous rulemakings, almost all combination truck companies are small businesses.[101] However, we believe that most small operators and owner-operators would be unable to compensate for the delay in delivery time if a speed limiting device is required. It is our understanding that non-owner drivers, as independent contractors, are paid an average wage of $0.32 per mile[102] (the industry range is generally $0.27 to $0.42 per mile). On the other hand, for an owner-operator who drives his or her own trucks all revenue, the revenue as motor carrier received, less operating and other expenses, is profit. Even after expenses are subtracted, we suspect that the labor income of an owner-operator would be greater than or close to the upper range of the $0.27 - $0.42 for non-owner-drivers. In other words, the labor income of an owner-operator would be $0.42 per mile or greater.

[101] Preliminary Regulatory Evaluation for Electronic On-Board Recorders and Hours-of-Service Supporting Documents, U.S. Department of Transportation, Federal Motor Carrier Safety Administration, January 2011.
[102] Truck drivers earn about $40k per year (http://www.bls.gov/ooh/transportation-and-material-moving/heavy-and-tractor-trailer-truck-drivers.htm) and drive about 2,500 miles per week (2,000 – 3,000 miles per week). We assumed that truck drivers work for 50 weeks per year; thus, a total of 125K miles per year. $40k/125K miles = 0.32 per mile.

We have anecdotal information that 30% of the total travel distance by CMV drivers was from owner-operators. Thus, if combination truck drivers traveled a total of 81,778 million miles, annually, 24,533 million miles, 30% of the 81,778 million miles would be from owner-operators.

For the small business impact analysis, we assumed that there is no difference between company drivers and owner-operators in terms of driving hours. In addition, we assumed that owner-operators who drive at or near the maximum 11 driving hours would not have resources to purchase a new truck or hire another driver. Previously, for the 3% delay in delivery time with 65 mph speed limiters, we estimated that approximately 2% of CMV drivers would not be able to deliver the same amount of payload within the required 11 driving hours. However, some of the owner-operators who are unable to make profits in the new environment would work for trucking companies as independent contractors who are paid on average $0.32 per mile ($0.27 to $0.42 per mile). If 100 percent of these owner-operators are hired as independent contractors, the overall labor income for these drivers would be on average $141 million with 65 mph speed limiters, compared to $185 million as owner-operators, for the estimated 3% increase in delivery time. Therefore, under the assumptions, owner-operators could potentially lose $44 million in labor income (24,533 million miles x 2% = 440 million miles, 440 million miles x $0.42/mile = $185M, whereas 440 million miles x $0.32/mile = $141M, $185M - $141M = $44M).[103]

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[103] According to ATRI, "The Role of Speed Limiting devices in Truck Safety Industry Speed Limiting device Use Survey, Preliminary Analysis", March 2007, there was a statistically significant inverse correction between limiting device speed and fleet size. According to the report, 33.3% of small carriers (with 10 or fewer trucks) and 34.2% of medium size carriers (with 11 to 100 trucks) set limiting device speeds higher than 70 mph, whereas only 15% of large size trucking companies chose to do so. Similarly, 32.5% of large size carriers chose a speed setting of 65

Table 106
Loss of combination truck owner-operator labor income with a 65 mph speed limiting device

Increase in delivery time	Potential loss
3%	$44

For single unit truck and bus small businesses, we have limited data. Accordingly, for single unit trucks, we used the combination truck driving data as a proxy for the impact on single unit truck owner operators. For buses, due to limited data, we assumed that all bus companies are small business[104]. Overall, for example, we estimated that heavy vehicle owner operators would lose $54 million in labor income when a 65 mph speed limiting device is used. (See Appendix G for the calculation used.)

Table 107
Loss of owner-operator labor income with a 65 mph speed limiting device, in $M*

Vehicle type	Potential loss
Combination truck	$44
Sing unit truck	$6
Buses	$5
Total	$54

* Numbers are rounded to the nearest integer.

Competitiveness:

The competitive impacts on small trucking companies are very hard to analyze. One of the greatest concerns of a speed limiting device mandate to owner-operators is the effect it will have on their competitiveness. Research has been done to examine the relationship between the

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mph or lower while 27.6% of small size carriers and 15.8% of medium size carriers chose the 65 mph and lower speed setting.

[104] Most bus companies are small companies. The most common fleet size is 1 power unit (interstate). Motor Carrier Management Information Systems (MCMIS).

productivity benefits lost and the fuel savings gained due to the use of speed limiting devices. An analysis by Ray Barton Associates examined a hypothetical maximum productivity level to determine costs.[105] Three speeds were examined at 65, 70 and 75 mph. However, the effect on an individual depends on that person's position within the trucking company. The fleet owner will benefit from the slower speed and increased fuel efficiency, but a truck driver's labor income (assuming he/she is paid on a per mile basis) is reduced by 6.5% traveling 65 mph versus 70 mph. Since an owner-operator is both the owner and driver, he/she will experience both the effects on fleets and on drivers. In general, if 65 mph speed limiters are used his/her revenue will be lower at 65 mph, but his/her net income will be greater at 65 mph because of the savings.

Owner-operators and small fleet owners feel that they will be put at a significant disadvantage if speed limiting devices are mandated, asserting that there are too many factors working against them.[106] Currently, in some cases, they can bid on jobs and arrive sooner compared to a firm that already voluntarily uses a speed limiting device, if the small company or owner-operator can drive as fast at 75 mph, which is the speed limit on some roads. Thus, it is likely that there currently are some jobs where there is a competitive advantage to being able to drive faster, and this advantage would be eliminated by a nationwide requirement on speed limiting devices. In addition, if travel speeds are limited, small independent truck companies (especially owner operators) might not be able to expand quickly enough to hire the additional drivers needed to carry existing freight which will come about because of the lower travel speed. Because small

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[105] http://www.worldcat.org/title/final-report-trade-and-competitiveness-assessment-of-mandated-speed-limiters-for-heavy-trucks-operating-in-canada-2008/oclc/874234190
[106] Markus, do we have cite for this?

independent trucking companies are less able or unable to hire additional drivers, the large trucking companies will likely absorb the additional cargo with their additional resources, especially trucks and drivers. As a result, we expect that the overall travel distance by trucks owned by small independent trucking companies would decrease as the travel distance by trucks owned by large trucking companies increases. Although we do not expect the proposed speed limiting device requirements to result in additional net cost to the truck industry as a whole, some small trucking companies may not be able to command a price premium for delivering loads faster or be able to deliver enough loads to be profitable with speed limiting devices.

We note that some of small trucking companies especially owner-operators would lose the market if the driver currently is driving at or near the maximum allowable hours with a speed limiting device. The market lost by the owner-operators would be an opportunity for large trucking companies to expand their market share. Total market size does not change, but there is a transfer market share from the owner operator to the large trucking company. For the newly captured market, large trucking companies would hire new drivers and utilize their current fleet of trucks. The cost for capturing the newly expanded market would be estimated by multiplying the $/mile with the total vehicle miles captured. This cost is compensated by the expected increase in profit from the expanded market. In addition, those owner-operators who lost the market would have a few choices, including working for large trucking companies. When an owner-operator decides to work for large trucking companies as an independent contractor, we assumed that they would be paid by the industry average $/mile. Further, we assumed that the current owner operators are making higher income with a higher rate per miles driven (i.e., $/mile) when compared to the industry average $/mile. Consequently, these owner-operators would lose part of their income when they work for large trucking companies as an independent contractor.[107] Alternatively, when owner operators are forced to drive at a lower speed, they travel fewer miles and make less money. We assumed that the labor income would decrease proportionally with the decrease in miles traveled.

Impacts on Commercial Vehicle Driver Employment:

Previously we estimated that combination truck trucking companies would hire additional drivers to cover the delay in delivery time. We expect that the trucking companies would hire the additional drivers as either company employees or independent contractors. In the cost chapter, with 65 mph speed limiters, we estimated that the cost to hire new drivers would range from $16.4 million under Scenario 1 and $151 million under Scenario 2. (The scenarios are further discussed in Benefits chapter.) For example, by assuming combination trucks would travel at 65 mph on rural and urban interest highways, we expect that combination truck trucking companies would hire roughly 4,000 new drivers.[108] With 1.5 million truck drivers in the U.S, therefore, the proposal would increase employment in this segment of the industry by 0.3%.[109]

Fuel savings for small business:

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[107] However, these owner-operators also will not have to bear some costs associated with being owner-operators such as finding loads, which could be handled by the fleet they contract with.
[108] On average combination truck drivers earn $40,940 annually (per US Labor Dep, BLS, http://www.bls.gov/oes/current/oes_nat htm#53-0000). For the lower range of $16.4 million, the number of drivers would be 400 ($16,400,000/$40,940 = 400); for the upper range, we expect 28,578 new drivers ($151,000,000/$40,940 = 3,688). 3,688/1,500,000 = 0.3%
[109] The drivers are for trucks with a GVWR greater than 11,793 kg (26,000 lbs.), Bureau of Labor Statistics, May 2010.
http://www.bls.gov/oes/current/oes533032 htm

VMT and vehicle travel speed are two critical factors affecting fuel consumption. We have limited data on the total VMT by small trucking companies indicating that VMT by these companies is 30% of total VMT, but we do not have any data on how fast trucks operated by small companies travel on highways when compared to trucks operated by large companies. If we assume that there is no difference in travel speed between trucks operated by small companies and those operated by large trucking companies, we could distribute the estimated fuel saving by the percent VMT by small and large trucking companies. Under the assumption, 30% of the fuel savings resulting from the proposed rule would be realized by the small trucking companies.

Note that because trucks operated by large trucking companies are more likely to have speed limiting devices than trucks operated by small companies, it is likely that trucks operated by large trucking companies travel at lower speeds than trucks operated by small trucking companies. If this is true, limiting truck speeds would result in higher relative fuel savings (i.e., higher than 30% of total fuel savings) for small trucking companies because the reduction in travel speed would be greater for trucks operated by those companies. In order to improve our estimate, which, as mentioned above, is based on limited data and certain assumptions, the agencies request comments on VMT and vehicle travel speed by the size of truck carriers and bus companies.

IV. COST-EFFECTIVENESS AND BENEFIT-COST ANALYSES

The intent of the proposed rulemaking is to minimize deaths and injuries by limiting travel speed of heavy vehicles on highways. In previous chapters, the agencies examined the benefits and costs of heavy vehicle speed limiting devices set at a particular speed.

Throughout this analysis, to simplify matters, we will show how we calculated benefits and costs for speed limiters set to 65 mph, and primarily for combination trucks. However, we have also considered and made identical calculations for single-unit trucks and buses and for all three vehicle types with speed limiters set to 60 mph and 68 mph. The NPRM does not propose a specific set speed requirement, but the agency would specify a maximum set speed in a final rule implementing this proposal.[110]

Effective January 1, 2004, OMB Circular A-4 requires that analyses performed in support of rules must include both cost effectiveness and benefit-cost analysis. Benefit-cost analysis differs from cost effectiveness analysis in that it requires that benefits be assigned a monetary value, and that this value be compared to the monetary value of costs to derive a net benefit.

When accounting for the benefits of safety measures, cost savings not included in value of life measurements must also be accounted for. Value of life measurements inherently include a value for lost quality of life plus a valuation of lost material consumption that is represented by

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[110] Results for 60 mph and 68 mph speed limiters are reported in Appendix I.

measuring consumer's after-tax lost productivity. In addition to these factors, preventing a motor vehicle fatality will reduce costs for medical care, emergency services, insurance administrative costs, workplace costs, and legal costs. The sum of both value of life and economic cost impacts is referred to as the comprehensive cost savings from reducing fatalities.

In order to estimate the net benefits of the rulemaking, nonfatal injuries are expressed in terms of fatalities. This is done by comparing the value of preventing nonfatal injuries to the value of preventing a fatality. Comprehensive values, which include both economic impacts and lost quality (or value) of life considerations are used to determine the relative value of fatalities and nonfatal injuries. Using these values, we calculate equivalent lives saved (ELS) conversion factors. These factors are shown in Table 110.

Safety Benefits:
According to the benefit estimate analysis, for example, a 65 mph speed limiting device would save 63 - 214 lives, annually. The odds ratios used for the safety benefit analysis are shown below:

Table 108
Odds Ratios Used for Safety Benefit Estimate

		Speed distribution, multivariable	Mean speed, multivariable
CT	Vehicle-based	1.047	1.154
	Person-based	1.033	1.150
SUT	Vehicle-based	1.014	1.079
	Person-based	1.035	1.097
BUS	Vehicle-based	0.996	1.081
	Person-based	1.024	1.165

Combination trucks, vehicle-based approach with speed distribution:
For combination trucks, the vehicle-based multivariable approach resulted in an odds ratio of 1.047 with the speed distribution. Based on the vehicle-based multivariable approach, for example, the number of lives saved was estimated to be 84 lives with 65 mph speed limiters. In addition, we expect 93 serious injuries (MASI 3-5) and 1,737 minor injuries (MAIS 1-2) would be prevented with 65 mph speed limiters.

Table 109
Estimated Number of Occupants fatal and non-fatal Injuries prevented
with vehicle-based multivariable approach and speed distribution, with 65 mph speed limiters

Injury	Prevented
MAIS 1	1,536
MAIS 2	201
MAIS 3	77
MAIS 4	10
MAIS 5	5
Lives saved	84

With the relative conversion factors, the injuries were converted into Equivalent Lives Save (ELS).

Table 110
ELS for combination trucks, with vehicle-based multivariable approach and speed distribution

Injury Severity	Prevented	ELS Conversion Factor	ELS, lower (Undiscounted)
MAIS 1	1,536	0.003	4.61
MAIS 2	201	0.047	9.43
MAIS 3	77	0.105	8.12
MAIS 4	10	0.266	2.78
MAIS 5	5	0.593	2.90
Fatal	84	1.0000	84
Total		n/a	111.71

The results in Table 110show that, for example, a 65 mph speed limiting device would save 112 equivalent fatalities (111.71 ELS). The 112 ELS were discounted to express their present value over the lifetime of one model year's production, as discussed in the following section.

Total benefits are derived by multiplying the value of life by the equivalent lives saved. In 2014, the Department of Transportation issued revised guidance regarding the treatment of value of a statistical life (VSL) in regulatory analyses. The new guidance establishes a VSL of $9.2 million for analyses based on 2013 dollars.

Monetized Benefits in our Net Impacts Section have been typically estimated by multiplying the comprehensive costs times the equivalent lives saved. In the analysis, comprehensive costs are separated into two calculations – Economic Costs and Value of Statistical Life (VSL). (See Appendix C for additional discussion on VSL.) The equivalent lives saved were discounted to present value at 3 and 7 percent per OMB Circular A-4 where 3 percent represents the "social rate of time preference," and 7 percent represents the average rate of return to capital.

For the socioeconomic costs/savings and the other savings, the vehicle survivability (i.e., exposure rate) and the vehicle miles traveled (VMT) were used to derive a multiplier of 0.8095 at 3% and a multiplier of 0.6427 at 7% discount rates. (See Appendix D for additional discussion on the discount factors.) The discount factors and the discounted fatal equivalents are summarized in Table 111.

Table 111
Equivalent lives saved with 65 mph speed limiting devices, combination trucks, with vehicle-based multivariable approach and speed distribution

Fatal and non-fatal injuries prevented	ELS		
	No-discount	3%	7%
	1.0000	0.8095	0.6427
Total	111.71	90.43	71.80

The discounted fatal equivalents in Table 111 show that 65 mph speed limiting devices would save 90 (90.43) and 72 (71.80) equivalent lives annually when discounted at 3% and 7%, respectively, for combination trucks based on the vehicle-based multivariable approach with the speed distribution .

Other Benefits:
In addition to the safety benefits, we considered fuel savings, GHG savings and property savings. When the fuel, GHG, societal economic, and property damage savings were considered, for example, with 65 mph speed limiters, the annual total benefit for combination trucks based on the vehicle-based multivariable approach with the speed distribution was estimated to be $1.7 billion discounted at 7%, as shown in Table 113.[111]

We note that there would not be any incremental costs to manufacturers associated with installing speed limiting devices, given that the affected vehicles already have speed-limiting capability. However, truck and bus companies would likely hire additional drivers to compensate the delay in delivery and travel time with a 65 mph speed limiting device. Although we expect the labor cost would increase with the proposed speed limiting device, the fuel savings from the proposed rule would be far greater than the costs associated with hiring additional drivers. Therefore, with the positive safety and fuel saving benefits, the proposed rule would be cost beneficial. Since the fuel economy benefits outweigh costs, we believe there is no reason to estimate the costs per equivalent life saved.

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[111] All fuel savings estimates presented in this section use the proposed phase 2 MD/HD fuel economy standards as the primary baseline.

The net benefits for combination trucks resulting from large and small trucking companies are combined for the net benefit calculation.

For the combination trucks based on the vehicle-based multivariable approach with the speed distribution, for example, with 65 mph speed limiters, the net benefits were estimated to be $1,560 million at 3% and $1,250 million at 7%.

Table 112
Net benefit, combination trucks, with 65 mph speed limiting devices, with vehicle-based multivariable approach and speed distribution, in M's, 2013 dollars*

CT	3%	7%
Safety VSL benefit	$832	$661
Fuel saving, phase 2	$796	$632
GHG saving	$150	$119
Societal economic injury savings	$268	$224
Property damage savings	$90	$71
(Equipment cost)	$0	$0
(Opportunity lost cost)	$566	$449
(Inventory cost)	$11	$8
Net benefit	$1,560	$1,250

* The numbers are rounded to the nearest integer.

Table 113
Net benefit, combination trucks, with 65 mph speed limiting devices, with vehicle-based multivariable approach and speed distribution in M's

CT, Net benefit	3%	7%
Benefits	$2,137	$1,708
Costs including inventory cost	$577	$458
Net benefit, in M's	**$1,560**	**$1,250**

Table 114
Net benefit showing excluding fuel and GHG saving, combination trucks, with 65 mph speed limiting devices, with vehicle-based multivariable approach and speed distribution, in M's

CT, Net benefit without fuel & GHG savings	3%	7%
Benefits	$1,190	$956
Costs including inventory cost	$577	$458
Net benefit w/o fuel and GHG savings	$613	$499

Table 115
Net benefit showing net costs, combination trucks, with 65 mph speed limiting devices, with vehicle-based multivariable approach and speed distribution, in M's

Benefits	$1,190	$956
Net Costs (Net cost = Cost - Fuel &GHG savings)	-$370	-$294
Net benefit	$1,560	$1,250

Similar to the approach used for combination trucks, we estimated the net benefits for the remaining approaches, as shown in the following tables.

Table 116
Number of lives saved for combination trucks by odds ratio

CT	Vehicle-based		Person-based	
Odds ratio	1.047	1.154	1.033	1.150
Lives saved	84	204	62	201

Table 117
Net benefits for combination trucks by odds ratio, in 2013 dollars

CT			Vehicle-based		Person-based	
Odds Ratio		Discount	1.047	1.154	1.033	1.150
Benefit	Safety& Property	3%	$1,190	$2,888	$879	$2,853
		7%	$956	$2,322	$706	$2,293
	Fuel & GHG	3%	$947	$947	$947	$947
		7%	$752	$752	$752	$752
	Total Benefits	3%	$2,137	$3,835	$1,826	$3,800
		7%	$1,708	$3,074	$1,458	$3,045
Cost		3%	$577	$577	$577	$577
		7%	$458	$458	$458	$458
Net Benefit		3%	$1,560	$3,258	$1,249	$3,223
		7%	$1,250	$2,616	$1,000	$2,587

Table 118
Number of lives saved for SUTs by odds ratio

SUT	Vehicle-based		Person-based	
Odds ratio	1.014	1.079	1.035	1.097
Lives saved	1	4	2	5

Table 119
Net benefits for SUTs by odds ratio

SUT			Vehicle-based		Person-based	
Odds Ratio		Discount	1.014	1.079	1.035	1.097
Benefit	Safety& Property	3%	$12	$56	$29	$66
		7%	$10	$45	$23	$53
	Fuel & GHG	3%	$96	$96	$96	$96
		7%	$75	$75	$75	$75
	Total Benefits	3%	$108	$152	$125	$162
		7%	$85	$120	$98	$128
Cost		3%	$67	$67	$67	$67
		7%	$53	$53	$53	$53
Net Benefit		3%	$41	$85	$58	$95
		7%	$32	$67	$45	$75

Table 120
Number of lives saved for buses by odds ratio

Bus	Vehicle-based		Person-based	
Odds ratio	0.996	1.081	1.024	1.165
Lives saved	0	3	1	5

Table 121
Net benefits for buses by odds ratio

Bus			Vehicle-based		Person-based	
Odds Ratio		Discount	0.996	1.081	1.024	1.165
Benefit	Safety& Property	3%	$0	$42	$16	$73
		7%	$0	$33	$13	$58
	Fuel & GHG	3%	$26	$26	$26	$26
		7%	$21	$21	$21	$21
	Total Benefits	3%	$26	$68	$42	$99
		7%	$21	$54	$34	$79
Cost		3%	$16	$16	$16	$16
		7%	$13	$13	$13	$13
Net Benefit		3%	$10	$52	$26	$83
		7%	$8	$41	$21	$66

In summary, for example, with 65 mph speed limiters, the net benefit ranges from $1,000 million to $2,616 million for combination trucks discounted at 7%. For single unit trucks, the net benefit ranges from $32 million to $75 million discounted at 7%. For buses, the net benefit ranges from $8 million to $66 million discounted at 7%.

Table 122
Overall net benefits by vehicle type, discounted at 3% and 7%, in millions, with 65 mph speed limiters, in 2013 dollars

Vehicle	3%		7%	
	Lower	Upper	Lower	Upper
CT	$1,249	$3,258	$1,000	$2,616
SUT	$41	$95	$32	$75
Bus	$10	$83	$8	$66

Net impacts on fleets:

Our analysis indicates that the total value of fuel savings to all operators from setting speed limiters to no more than 65 mph for all operations at all times and in all locations of the country substantially exceeds the cost of doing so.[112] As a general matter, firms are presumed to be profit-maximizers, and will choose the most efficient bundle of inputs to produce the desired level of output based on the prices and marginal products of those inputs. In this case, the profit-maximizing firm would set speed limiters if it would result in net savings to them and would not set them if net savings would not result. Some in the trucking industry voluntarily speed limit their trucks, while others do not.[113] Because our analysis indicates that the industry operating

[112] This section focuses only on the estimates of fuel savings and costs experienced by truck owners/operators. It does not address the broader set of overall effects of speed limiters. Specifically, this section does not address safety considerations that influence the decision-making of fleets considering the use of speed limiters.

[113] See, for example, Transportation Research Board. (2008). CTBSSP Synthesis 16: Safety Impacts of Speed Limiter Device Installations on Commercial Trucks and Buses. Transportation Research Board, Washington, DC. http://onlinepubs.trb.org/onlinepubs/ctbssp/ctbssp_syn_16.pdf . Also see, American Transportation Research Institute. (2014). An Analysis of the Operational Costs of Trucking, a 2014

profit as whole may benefit by slowing these vehicles down, the question then arises, "if, it is in the industry's best interest to adopt speed limiters, why don't they all do so voluntarily?"

In order to answer the question, we examined how fuel and labor costs can affect an individual truck operators' decision-making process. When fleet vehicles are equipped with speed limiters set at speeds below the maximum that the vehicles would otherwise travel but above or equal to the vehicles' optimal speed for fuel efficiency, fuel savings will result. On the other hand, fleets will incur costs due to the additional time needed to make deliveries, which could require that they hire additional drivers or have existing drivers work longer hours and shippers and receivers may also incur costs, particularly for time-sensitive shipments (which, in a competitive environment, would ultimately be reflected as a cost to carriers in the form of lower shipping rates). Further, the fleet fuel and labor costs that truck owners respond to are different than the societal value of those costs that we use in the cost-benefit analysis. Societal costs exclude taxes and other transfer payments from one group to another that have no effect on the total resources available to society. However, taxes paid by truck owners affect their decision whether to use speed limiters on their vehicles. In other words the value of fuel savings to truck operators is generally larger than the value to society. Similarly, the expenditures by firms on labor is generally larger than the value to society because of the taxes and other transfers associated with

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Update. American Transportation Research Institute, Arlington, VA. http://atri-online.org/wp-content/uploads/2014/09/ATRI-Operational-Costs-of-Trucking-2014-FINAL.pdf employing workers (income tax, social security and Medicare tax, unemployment insurance, etc).

Based on average driver wages, we estimate that a 65 mph speed limiter would result in fuel savings benefits that are greater than costs by $144M - $694M for combination trucks, $5M - $70M for SUTs and $10M - $19M for bus drivers, discounted at 7% in 2013 dollars. We note that the fleet net benefits are based on the current average wages. Since the speed limiters would require additional drivers, the labor costs would increase when applicable vehicles are required to have speed limiters.

Table 123
Fleet net costs, combination trucks, with 65 mph speed limiters, based on average wage ($20.08), in millions, in 2013 dollars

Fleet savings and costs	Scenario 1		Scenario 2	
	3%	7%	3%	7%
Fuel savings	$902	$716	$902	$716
Cost to hire new drivers	$18	$14	$710	$564
Inventory costs	$11	$8	$11	$8
Net benefits	$873	$694	$181	$144

Table 124
Fleet net costs, SUTs, with 65 mph speed limiters, based on estimated average wage ($20.08), in millions, in 2013 dollars

Fleet savings and costs	Scenario 1		Scenario 2	
	3%	7%	3%	7%
Fuel savings	$90	$72	$90	$72
Cost to hire new drivers	$2.1	$1.7	$83	$66
Inventory costs	$0.9	$0.7	$0.9	$0.7
Net benefits	$87	$70	$6	$5

Table 125
Fleet net costs, buses, with 65 mph speed limiters, based on average wage ($18.95), in millions, in 2013 dollars

Fleet savings and costs	Scenario 1		Scenario 2	
	3%	7%	3%	7%
Fuel savings	$24	$19	$24	$19
Cost to hire new drivers	$0.5	$0.4	$11.9	$9.5
Net benefits	$24	$19	$12	$10

Our calculations of fuel savings and labor costs thus indicate a net benefit, and thus a higher profit for trucking firms in aggregate from using speed limiters. However, although a significant portion of the truck fleet has voluntarily adopted these devices, some have not. Possible reasons for this include:.

1. Regional and other variations in fuel and labor prices may make using speed limiters more profitable to some fleets than others.
2. The savings resulting from speed limiters are small for a single vehicle relative to its total operating cost and are sensitive to unpredictable future changes in fuel prices.
3. Operators may not know precisely how much money they can save from driving slower.

We address each of these in more detail below. We seek comment on each explanation or other plausible explanations that we have not identified. Further, we stress at the outset that this discussion solely concerns whether there are reasons why the estimated fuel savings might incorrectly be projected to exceed the estimated costs for some trucking firms; it does not suggest that the estimated safety benefits or emissions reductions, which in nearly all scenarios also outweigh the costs, do not on their own justify a rulemaking based upon our projected analysis.

First, the fleet fuel and labor costs can enter into individual trucker's decisions differently because there is variation in those costs across trucking fleets. Fuel costs vary by state due to regional variation in supply and demand, regional delivery cost differences, and variation in state taxes. Truckers that deliver predominately in one region or across different regions may thus face different fuel cost considerations. Fleet operators also face different wage burdens. More experienced truckers can make 50 percent higher wages than less experienced truckers (see Table 126 below). Further, these truckers are typically more efficient drivers and potential savings from limiting speed may be less cost effective for them.

For combination trucks, for example, with 65 mph speed limiters, based on the average estimated cost of fuel, the fuel savings were estimated to be $716 million based on the after-tax fuel cost[114] discounted at 7%. In some cases, as demonstrated by Scenario 2, which assumes that drivers employed by large trucking & bus companies are paid the same amount/income for the fewer miles driven with the same amount of driving hours, trucking companies would need to spend a total of $564 million to hire new drivers based on the <u>average</u> truck driver wages ($20.08 hourly + 55% fringe benefits = $31.12 per hour.) Based on the <u>median</u> wages, the cost would be $548 million ($19.36 hourly +55% fringe benefits = $30.01). Under these circumstances, it would make sense for trucking companies to use speed limiters because they gain more in decreased fuel than the added cost of labor.

However, the fleet fuel savings can be smaller than the increase in operation cost when trucking companies have to hire experienced drivers for high wages, particularly if the fuel costs in the region are relatively low. For example, under Scenario 2, combination truck companies would save $716 million in fuel (based on the after-tax gasoline price of $3.663 per gallon). However, at higher wages (for example, 90 percentile), the increase in operational cost would exceed the

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[114] After-tax fuel cost refers to the cost of fuel paid at the pump including taxes.

average fuel savings. If fuel prices are lower, a larger portion of the labor force would have wages that produce net losses for fleets. The need to pay higher wages may occur naturally as truckers become more experienced, or periodically when the demand for truckers exceeds the supply. The bottom line is that while speed limiters may make economic sense in most circumstances, in some circumstances, fleet managers may decide that they are not economical, or that they simply do not know enough regarding long-term fuel prices and wages to require them. Thus, some portion of heavy truck fleets may decide not to use speed limiters.

Table 126
Hourly wage vs operational costs for trucking companies, with 65 mph speed limiter, in millions[115]

Percentile:	50% (Median)	75%	90%
Hourly Wage:	$19.36	$24.13	$29.81
Increase in operational cost, in M's:	$548	$686	$845
Fuel saving, after-tax, in M's:	$716	$716	$716
Net saving for fleet, in M's:	$168	$30	-$129

Table 127
Fleet fuel savings (with after-tax fuel cost) with 65 mph speed limiter, in millions

Vehicle	Gallons	Total	3%	7%
CT	304	$1,115	$902	$716
SUT	32	$111	$90	$72
Bus	8	$30	$24	$19
total	344	$1,256	$1,017	$807

Second, the expected fuel savings from 65 mph speed limiters are potentially small for an individual owner-operators or small fleets and can be very sensitive to retail fuel prices. For example, in 2013 the average combination truck traveled 68,155 miles and the average hourly

[115] BLS http://www.bls.gov/oes/current/oes533032.htm

rate for a general freight operator was $20.08. If the speed limiter setting for a single truck was decreased from 70 mph to 65 mph, moving goods would take 27 hours longer each year, costing $542 for additional labor for the year. This cost would be offset by saving 196 gallons of fuel. In order to understand if such a company policy would be financially beneficial to the operation, the price of fuel (including taxes paid by the fleet) must be considered. In this case, if the price of fuel is less than $2.77 per gallon ($542/196 = $2.77/gallon), limiting the speed setting from 70 mph to 65 mph would not be financially beneficial, but if the price of fuel were greater than $2.77 it would be.[116] Over time, fuel prices can be volatile, varying by dollars per gallon over a period of years. Considering that the price of fuel fluctuates, the discrepancy between various fleets' speed settings, or no setting, could be caused by differences in the projected price of fuel for the year, or by the uncertainty caused by these fluctuations. For example, the operation cost of a single combination truck is around $100,000 annually.[117] Hypothetically at $4.00 per gallon, the net savings resulting from limiting a truck from 70 mph down to 60 mph would be $775, or 0.7% of the total operating cost. Given that the cost savings that can be achieved by the use of a speed limiter are small relative to the total cost of operation, and that these cost savings fluctuate based on the price of fuel, voluntarily utilizing a speed limiter for a small fleet may not be an advisable choice for fleet managers based on cost alone. Even in cases where an actual accounting of fuel benefits would indicate that limiting speed is beneficial under existing

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[116] We note that if retail fuel prices are less than $2.77 per gallon, it may still be financially beneficial for the average truck to limit speed to, for example, 68 mph (with 65 mph speed limiters, the threshold fuel unit cost was estimated to be $2.51).

[117] An Analysis of the Operational, Costs of Trucking: An Analysis of the Operational Costs of trucking: 2014 Update
September 2014, W. Ford Torrey, IV, Research Associate American Transportation Research Institute, Atlanta, GA (See Table 7, 68,155 miles x $1.676/mile = $114,227 in 2013 dollars)

conditions, the truck operator may not realize this because changing conditions would require him to constantly re-evaluate his position.

Third, for small trucking companies or owner-operators to decide if speed limiters would save them money, they have to know how speed limiters save them money. The most practical way to determine how speed limiters save them money may be to experiment with their trucks. That experimentation entails both cost and risk. The agency does not know the extent to which this is the reason for the decisions of some operators not to set certain speeds. The agency seeks comment on the extent of this potential problem and on the extent to which providing information and guidance to operators on the benefits and costs of speed limiters (such as through EPA's Smart Way program described below) would address this potential problem.
In sum, the potential for fuel savings may not create sufficient incentive for truck drivers to slow down voluntarily in all cases. If incentives are insufficient due to market failure, then trucking firms may be consuming more fuel than is optimal.

We note that, the valuations of the benefit of the fuel savings or the cost of additional labor is are not certain. Although most firms have voluntarily adopted speed limiters, data limitations inhibit our ability to precisely determine the overall impact on the industry. Our estimates often rely on data and assumptions that are less specific than would be ideal. For example, the assumptions we use to value travel time and lost opportunity cost may not capture the valuations used by individual truckers or trucking firms. Were such data available, we might find that speed limiters were either more or less cost-beneficial than we currently estimate.

One limitation in the data supporting this analysis is that there is little information about the percentage of trucks that are speed limited, and the speeds existing speed limiters are set to. Thus, we can only theorize on why some trucks are using speed limiters and some trucks are not. A speed limiter requirement would only affect those trucks that are not using speed limiters and are actually driving faster than the set speed requirement. However, our speed estimates are based on observed speeds of individual trucks on various highways and do not include any data on the use of speed limiters. The agencies seek comment on how to obtain the data necessary to conduct an analysis of only operators not currently using speed limiters.

Our valuation of the factors affecting the use of speed limiters is also not certain. For example, our valuation of the fuel savings may not be precise. Aside from the uncertainty inherent in predicting the future price of fuel, our estimates of the amount of fuel saved from the use of speed limiters may be too high[118]. It is also possible that our valuation of delay may be too low. Either or both of our valuations of drivers' time or the loss of value of cargo due to delay could be incorrect. We have limited information how much of a premium, all things being equal, an urgent delivery commands a higher premium in the shipping market compared to a non-urgent delivery. We seek comment on the completeness and accuracy of both the fuel savings and cost estimates to truck operators.

A separate possible limitation in the analysis described above is that it aggregates the benefits and costs to all operators, including those currently using speed limiters as well as those that

[118] Note that they may also be too low. Uncertainty applies equally in either direction for estimates of costs and benefits, and the net impact could thus be higher or lower. However, in the context of this discussion, we are examining only those that might produce an overly optimistic result.

choose not to use them. The fuel savings and labor estimates are aggregated and valued based upon estimated national average of future fuel and labor costs. The regional variations described above may result in the use of speed limiters being more prevalent in regions with higher fuel prices and/or lower labor costs. Thus, it is possible that the costs and benefits of this rule may be disproportionately borne by firms with lower fuel prices and/or higher labor costs than the national averages. This could result in us either (or both) overestimating the fuel savings or underestimating the labor costs of this rulemaking. Generally, however, we believe that the aggregate benefits and costs we measure should reflect the impact of those who are driving at higher speeds in excess of the proposed limit.

Another unquantified effect that could impact the cost savings projected by this proposal is the potential for increase in truck driver pay. Our estimate is that 4,000 additional drivers would need to be hired if the agencies required speed limiters to be set to 65 mph, for example. It is possible that an increase in demand for drivers could cause the wage rates for all drivers to be increased. The increased wages would be paid to drivers with the cost savings that fleets would realize through lower fuel costs.

With regard to the fact that future fuel and other operating costs are uncertain and variable, it is also possible that a speed limiter standard that cannot vary with changing fuel and/or labor prices could be either less or more cost-effective than we measure here. As noted above it is clear that, with regard to fuel savings, the value of setting the limiter at a certain speed depends on several variables that do in fact vary with time, location and other factors. These include fuel prices and time-sensitive operating costs, including driver pay and the time-sensitivity of the shipment. Thus it is possible that establishing a uniform national speed that may be beneficial to fleets in the aggregate will be less beneficial when retail fuel prices are low, driver time costs are high, and shipments in question is time sensitive, but more beneficial when these conditions reverse. One key feature of speed limiters is that the speed for any vehicle can be adjusted to respond to changing fuel and labor costs on short notice and at a limited expense. Thus a uniform national standard that is independent of these variables would eliminate the flexibility to respond to unpredicted changes in circumstances. The agency seeks comment any and all aspects of this discussion.

V. ALTERNATIVES

In addition to the set speed alternatives, we examined feasibility of alternatives based on technologies that could limit the speed of a heavy vehicle to the posted speed limit of the road. These technologies might include a GPS, vision system, vehicle to infrastructure communication, or other types of autonomous vehicle technology. Although we are not proposing these alternatives in the NPRM, the agencies request comment addressing the feasibility of such technologies as potential regulatory alternative options to the speed limiting device requirement with a set maximum speed. Use of these technologies could potentially have the effect of reducing fatalities while limiting the economic effects of this rule. Our preliminary conclusion is that requiring these technologies to limit vehicle speed would not be feasible and/or cost-effective at this time, but the agencies are seeking comments from the public on this preliminary conclusion. The agencies would not publish a final rule requiring speed limiters using these technologies without first publishing another proposed rule addressing them. The agencies also request comment on whether they should consider allowing GPS-based speed limiters, which adjust to the actual speed limits on roads, to be used as an alternative means of compliance if conventional speed limiters are required.

GPS-Based Alternative:

For the GPS-based potential regulatory alternative, the agencies are unsure of the feasibility of such an alternative and have requested comment on various issues related to such devices, including potential costs of installing and maintaining such technologies.

Since the equipment cost of any of these conceivable speed limiter technologies would be substantially higher and the benefits unlikely to exceed the additional cost, a speed limiter designed to limit vehicle speed to the speed limit of the road would not be as cost effective as this proposal. In addition, a GPS speed limiter system would not be tamper-proof since drivers can easily block a GPS signal, such as by wrapping aluminum foil around the GPS sensor. Furthermore, the GPS system would not be operational in areas where GPS signal is not detected such as under a bridge or tunnel.

V2I Technology

V2I technology is already being adopted in many cities and States. It is possible that vehicles could receive information about the posted speed limit from infrastructure communication systems (DSRC, Wi-Fi, etc). The limitations and costs of a GPS-based technology could be mitigated by relying on V2I and V2V communications. We seek comment on pursuing this potential regulatory alternative approach. In particular, we seek comment on the costs and benefits of using V2I technology to limit truck speed based on the posted speed limits.

Autonomous Vehicle Technology

Several light duty manufacturers are introducing autonomous vehicle (AV) technology. Another potential regulatory alternative that NHTSA could consider is incorporating any AV technology in trucks to limit speed of trucks to the posted speed limits. We seek comment on specific technologies, including vision-based systems relying on existing roadside signage, that could enable this capability and the costs and benefits of this approach.

Retrofit:

As a regulatory alternative to requiring a speed limiting device for new vehicles, we estimated the costs associated with retrofitting heavy vehicles with a speed limiting devices.

Although the number of lives saved and injuries prevented would be the same, the safety benefits would be achieved sooner if current vehicles with a GVWR greater than 11,793 kg (26,000 lbs.)

are equipped with a speed limiting device. The number of heavy vehicles manufactured in 1992 and later years that are still in use was estimated to be 2 million.[119] Among the 2 million vehicles, about 40% of the vehicles would not be equipped with a speed limiting device. These vehicles could be retrofitted with a 65 mph speed limiting device. With an estimated $2,000 unit cost for retrofitting a heavy vehicle with an electronic speed limiting device, we estimated that the retrofitting cost would be over $3 billion in addition to the estimated $458M societal cost (at 7%) associated with the delay in delivery time and the inventory, if all applicable heavy vehicles are retrofitted with a 65 mph speed limiting device (see Appendix B for additional discussion).

[119] Based on the survivability table and the estimated 146,000 annual sales, we determined that 2 million Class 7&8 vehicles are still in use (2,090,145). Among the 2 million heavy vehicles, 1.2 million vehicles were MY 2002 or new model (1,217,764) that can be retrofitted with ECU and the remaining 0.8 million vehicles are too old to be fitted with ECU.

VII. INITIAL REGULATORY FLEXIBILITY ANALYSIS AND UNFUNDED MANDATES REFORM ACT ANALYSIS

A. Regulatory Flexibility Act

The Regulatory Flexibility Act of 1980, Pub. L. 96-354, 94 Stat. 1164 (5 U.S.C. §601 et seq.), as amended, requires agencies to evaluate the potential effects of their proposed and final rules on small businesses, small organizations, and small governmental jurisdictions in the United States.

Chapter 5 U.S.C. § 603 requires agencies to prepare and make available for public comment an initial regulatory flexibility analysis (IRFA) describing the impact of proposed rules on small entities if the agency determines that the rule may have a significant economic impact on a substantial number of small entities. Each IRFA must contain:

(1) A description of the reasons why action by the agency is being considered;

(2) A succinct statement of the objectives of, and legal basis for, the proposed rule;

(3) A description of and, where feasible, an estimate of the number of small entities to which the proposed rule will apply;

(4) A description of the projected reporting, record keeping and other compliance requirements of a proposed rule including an estimate of the classes of small entities which will be subject to the requirement and the type of professional skills necessary for preparation of the report or record;

(5) An identification, to the extent practicable, of all relevant Federal rules which may duplicate, overlap, or conflict with the proposed rule;

(6) Each initial regulatory flexibility analysis shall also contain a description of any significant alternatives to the proposed rule which accomplish the stated objectives of

applicable statutes and which minimize any significant economic impact of the proposed rule on small entities

1. Description of the reasons why action by the agency is being considered

Studies examining the relationship between travel speed and crash severity have confirmed the common-sense conclusion that the severity of a crash increases with increased travel speed.[120] In 2006, NHTSA received a petition from the American Trucking Associations (ATA) to initiate a rulemaking to amend the Federal Motor Vehicle Safety Standards (FMVSS) to require vehicle manufacturers to limit the speed of trucks with a Gross Vehicle Weight Rating (GVWR) greater than 26,000 pounds to no more than 68 miles per hour (mph). Concurrently, the ATA petitioned the FMCSA to amend the Federal Motor Carrier Safety Regulations (FMCSR) to prohibit owners and operators from adjusting the speed limiting devices in affected vehicles above 68 mph. That same year, FMCSA received a petition from Road Safe America to initiate a rulemaking to amend the FMCSRs to require that all trucks manufactured after 1990 with a GVWR greater than 26,000 pounds be equipped with electronic speed limiting systems set at not more than 68 mph. NHTSA published a notice in 2011 granting the petitions.

After conducting an analysis of crash data and data on heavy vehicle travel speeds, the agencies have determined that reducing heavy vehicle travel speed would reduce the severity of crashes involving these vehicles and reduce the number of resulting fatalities. After analyzing several

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[120] Johnson, Steven L. & Pawar, Naveen, Mack-Blackwell Rural Transportation Center, College of Engineering, University of Arkansas, Cost-Benefit Evaluation of Large Truck-Automobile Speed Limits Differentials on Rural Interstate Highways, MBTC 2048 (Nov. 2005).

set speeds, including 60 mph, 65 mph, and 68 mph, NHTSA is proposing to heavy vehicles to be equipped with a speed limiting system. As manufactured and sold, each of these vehicles would be required by NHTSA to have a speed limiting device to set a particular speed.

FMCSA is proposing a complementary Federal motor carrier safety regulation (FMCSR) requiring multipurpose passenger vehicles, trucks, and buses and school buses with a GVWR of more than 11,793.4 kilograms (26,000 pounds) to be equipped with a speed limiting system meeting the requirements of the proposed FMVSS applicable to the vehicle at the time of manufacture. Motor carriers operating such vehicles in interstate commerce would be required to maintain the speed limiting systems for the service life of the vehicle.

2. Objectives of, and legal basis for, the proposal or final rule

The objectives of the proposed rule are to reduce the severity of crashes involving heavy vehicles and reduce the number of fatalities.

Since this NPRM would apply both to vehicle manufacturers and motor carriers that purchase and operate these vehicles, this joint rulemaking is based on the authority of both NHTSA and FMCSA.

NHTSA's legal authority for the proposed rule is the National Traffic and Motor Vehicle Safety Act ("Motor Vehicle Safety Act"). Under 49 U.S.C. Chapter 301, Motor Vehicle Safety (49 U.S.C. 30101 et seq.), the Secretary of Transportation is responsible for prescribing motor vehicle safety standards that are practicable, meet the need for motor vehicle safety, and are stated in objective terms. "Motor vehicle safety standard" means a minimum performance standard for motor vehicles or motor vehicle equipment. When prescribing such standards, the Secretary must consider all relevant, available motor vehicle safety information. The Secretary must also consider whether a proposed standard is reasonable, practicable, and appropriate for the types of motor vehicles or motor vehicle equipment for which it is prescribed and the extent to which the standard will further the statutory purpose of reducing traffic accidents and associated deaths. The responsibility for promulgation of Federal motor vehicle safety standards is delegated to NHTSA.

FMCSA's proposed rule is based on the authority of the Motor Carrier Act of 1935 (1935 Act) and the Motor Carrier Safety Act of 1984 (1984 Act), both as amended. The two acts are delegated to FMCSA by 49 CFR 1.87(i) and (f), respectively.

The 1935 Act authorizes the Department of Transportation (DOT) to "prescribe requirements for — (1) qualifications and maximum hours of service of employees of, and safety of operation and equipment of, a motor carrier; and (2) qualifications and maximum hours of service of employees of, and standards of equipment of, a motor private carrier, when needed to promote safety of operations" [49 U.S.C. 31502(b)].

The 1984 Act confers on DOT authority to regulate drivers, motor carriers, and vehicle equipment. "At a minimum, the regulations shall ensure that — (1) commercial motor vehicles are maintained, equipped, loaded, and operated safely; (2) the responsibilities imposed on operators of commercial motor vehicles do not impair their ability to operate the vehicles safely; (3) the physical condition of operators of commercial motor vehicles is adequate to enable them to operate the vehicles safely . . . ; and (4) the operation of commercial motor vehicles does not have a deleterious effect on the physical condition of the operators" [49 U.S.C. 31136(a)(1)-(4)]. Sec. 32911 of the Moving Ahead for Progress in the 21st Century Act (MAP-21) [Pub. L. 112-141, 126 Stat. 405, July 6, 2012] recently enacted a fifth requirement, i.e., to ensure that "(5) an operator of a commercial motor vehicle is not coerced by a motor carrier, shipper, receiver, or transportation intermediary to operate a commercial motor vehicle in violation of a regulation promulgated under this section, or chapter 51 [Transportation of Hazardous Material] or chapter 313 [Commercial Motor Vehicles Operators] of this title" [49 U.S.C. 31136(a)(5)].

The 1984 Act also includes general authority to "(8) prescribe recordkeeping . . . requirements; . . . and (10) perform other acts the Secretary considers appropriate" [49 U.S.C. 31133(a)].

For a more extensive discussion of the agencies' legal bases for the proposed rules, please consult the NPRM.

<u>3. Description and estimate of the number of small entities to which the proposal or final rule will apply</u>

The proposed FMVSS would apply to manufacturers of multipurpose passenger vehicles, trucks, and buses, with a GVWR of more than 11,793.4 kilograms (26,000 pounds). The proposed FMCSR would apply to motor carriers operating such vehicles in interstate commerce.

<u>Vehicle Manufacturers</u>

Business entities are defined as small businesses using the North American Industry Classification System (NAICS) code, for the purposes of receiving Small Business Administration (SBA) assistance. One of the criteria for determining size, as stated in 13 CFR 121.201, is the number of employees in the firm. For establishments primarily engaged in manufacturing or assembling automobiles and light and medium/heavy duty trucks, buses, new tires, or motor vehicle body manufacturing, (NAICS code 336211) the firm must have less than 1,000 employees to be classified as a small business. In determining the number of employees, all employees from the parent company and its subsidiaries are considered and compared to the 1,000 employee threshold.

There are 34 manufacturers of medium/heavy trucks that report EWR information to NHTSA. The threshold for EWR reporting is the manufacture of 5,000 vehicles annually or more. We believe there are very few manufacturers of heavy trucks in the United States which can be considered small businesses. The heavy truck industry is highly concentrated with large manufacturers, including Daimler Trucks North America (Freightliner, Western Star), Navistar International, Mack Trucks Inc., PACCAR (Peterbilt and Kenworth) and Volvo Trucks North America, accounting for more than 99% of the annual production. We believe that the remaining trucks (less than 1 percent) are finished by final stage manufacturers. With production volume of less than 1 percent annually, these remaining heavy truck manufacturers are most likely small businesses.

NHTSA believes there are approximately 37 bus manufacturers in the United States. Of these, 27 bus manufacturers currently report EWR information to NHTSA and are believed to be large manufacturers. The remaining 10 manufacturers are believed to be small businesses. These 10 small volume bus manufacturers are listed in Table 128.

Table 128
Small Volume Bus Manufacturers

Advanced Bus Industries
Ebus Inc.
Enova Systems
Gillig Corporation
Krystal Koach Inc. a
Liberty Bus
Sunliner Coach Group LLC [b]
TMC Group Inc.
Transportation Collaborative, Inc. [c]
Van-Con, Inc.

[a] Krystal Koach Inc. is owned by Krystal Enterprises; $175M revenue; 800 employees.
[b] Sunliner's parent holding company is Stallion Bus Industries, LLC, which is the distribution arm of the organization.
[c] Transportation Collaborative, Inc. employs 140.

Motor Carriers

The motor carriers regulated by FMCSA operate in many different industries. Most for-hire property carriers fall under North American Industrial Classification System (NAICS) subsector 484, Truck Transportation, and most for-hire passenger transportation carriers fall under NAICS subsector 485, Transit and Ground Passenger Transportation. The SBA size standard for NAICS subsector 484 is currently $25.5 million in revenue per year, and the SBA size standard for NAICS subsector 485 is currently $14 million in revenue per year.

Because the agencies do not have direct revenue figures for all carriers, power units (PUs) serve as a proxy to determine the carrier size that would qualify as a small business given the SBA's revenue threshold. In order to produce this estimate, it is necessary to determine the average revenue generated by a PU unit.

With regard to truck PUs, FMCSA determined in the Electronic On-Board Recorders and Hours-of-Service Supporting Documents Rulemaking RIA[121] that a PU produces about $172,000 in revenue annually. According to the SBA, motor carriers of property with annual revenue of $25.5 million are considered small businesses.[122] This equates to 148 power units (148.26 = 25,500,000 / 172,000). Thus, FMCSA considers motor carriers of property with 148 PUs or fewer to be small businesses for purposes of this analysis. FMCSA then looked at the number and percentage of property carriers with recent activity that would fall under that definition (of having 148 power units or fewer). The results show that over 99 percent of all interstate property carriers with recent activity have 148 PUs or fewer, which amounts to about 493,000 carriers.[123] Therefore, the overwhelming majority of interstate carriers of property would be considered small entities.

[121] FMCSA Regulatory Analysis, "Hours of Service of Drivers; Driver Rest and Sleep for Safe Operations," Final Rule (68 FR 22456, April 23, 2003).
[122] U.S. Small Business Administration Table of Small Business Size Standards matched to North American Industry Classification (NAIC) System codes, effective July 22, 2013. See NAIC subsector 484, Truck Transportation.
[123] FMCSA MCMIS Data, dated 2011.

With regard to passenger-carrying vehicles, FMCSA conducted a preliminary analysis to estimate the average number of PUs for a small entity earning $14 million annually,[124] based on an assumption that passenger carriers generate annual revenues of $150,000 per PU. This estimate compares reasonably to the estimated average annual revenue per power unit for the trucking industry ($172,000). A lower estimate was used because passenger-carrying commercial motor vehicles (CMVs) generally do not accumulate as many vehicle miles traveled (VMT) per year as trucks, and it is therefore assumed that they would generate less revenue per PU on average. The analysis concluded that passenger carriers with 93 PUs or fewer ($14,000,000 divided by $150,000/PU = 93.3 PU) would be considered small entities. FMCSA then looked at the number and percentage of passenger carriers registered with FMCSA that have no more than 93 PUs. The results show that about 98% of active passenger carriers have 93 PUs or less, which is about 10,000 carriers. Therefore, the overwhelming majority of passenger carriers to which this NPRM would apply would be considered small entities.

Regarding bus companies, we believe that the companies most likely to be affected would be those that operate motorcoaches, which tend to be larger buses that are used for traveling longer distances. FMCSA data indicates that there are approximately 4,168 authorized motorcoach carriers, 813 of which own or lease only one motorcoach. The median number of motorcoaches owned or leased by these companies is 3. Accordingly, we estimate that most of the 4,168 motorcoach companies are small entities with annual revenues of less than $14 million per year.

[124] Motor carriers of passengers with an annual revenue of $14 million are considered small businesses. *See id.*, subsector 485, Transit and Ground Passenger Transportation.

The agencies request comments on the percentage of small carrier business that might be affected by the proposed speed limiting device requirements.

4. Description of the projected reporting, record keeping and other compliance requirements for small entities.

Vehicle Manufacturers

NHTSA is proposing to require multipurpose passenger vehicles, trucks, and buses, with a GVWR of more than 11,793.4 kilograms (26,000 pounds) to be equipped with a speed limiting system. As manufactured and sold, each of these vehicles would be required by NHTSA to have a speed limiting device. NHTSA is proposing a lead time of three years from publication of a final rule for manufacturers to meet the proposed requirements. The impact on manufacturers of heavy vehicles, whether they are large or small businesses, would be minimal, because these vehicles are already equipped with electronic engine controls that include the capability to limit the speed of the vehicle.

Motor Carriers

FMCSA is proposing a complementary Federal motor carrier safety regulation (FMCSR) requiring multipurpose passenger vehicles, trucks, and buses with a GVWR of more than 11,793.4 kilograms (26,000 pounds) to be equipped with a speed limiting system meeting the requirements of the proposed FMVSS applicable to the vehicle at the time of manufacture,.

Motor carriers operating such vehicles in interstate commerce would be required to maintain the speed limiting systems for the service life of the vehicle.

The impact on small carriers could be significant from a competitive perspective.

Regarding small trucking companies, the agencies predict that a speed limiting device might take away certain competitive advantages that small carriers might have over large trucking firms that already utilize speed limiting devices, but we have very limited knowledge of knowing whether that impact is 10 percent of their business, or more or less. We estimated that independent owner-operators of combination trucks and single unit trucks would drive 33,675 million miles annually out of 112,249 million miles traveled by these vehicles on rural and urban interstate highways. With the estimated average wage of $0.32/mile, the total annual revenue would be $10,776 million. As described in detail earlier in the PRIA, unlike large trucking companies, small carriers with limited resources may not be able to increase the number of drivers to overcome the delay in delivery time resulting from limiting their vehicles to 65 mph. However, the competitive impacts are difficult to estimate. For example, with 65 mph speed limiting devices, we estimated that owner-operators would lose $50 million annually. Accordingly, owner-operators would lose not more than 1% of their labor revenue. However, we note that the estimates were made based on very limited data. The agencies request comment on how large the economic impact might be on owner-operators.

Regarding small motorcoach companies, we have even more limited data to predict how affected small motorcoach companies would compensate for the delay in delivery time or to quantify the effect on those businesses. Like small trucking companies, small motorcoach companies might need additional drivers to cover the same routes with a speed limiting device if the speed limiting device reduces the distance they can travel within their maximum hours of service. If those companies were unable to hire additional drivers, they would likely lose market share to larger companies that could afford additional drivers.

The agencies believe that the proposed rule will affect small businesses, as discussed above; and may have a significant economic impact on a substantial number of small businesses. We request comment on the agencies' assumptions regarding how this rulemaking would affect small heavy vehicle operators, and we request comment on the type and magnitude of that effect

5. Duplication with other Federal rules

Vehicle Manufacturers

Although the heavy vehicle fuel efficiency program allows speed limiting devices as a compliance option for vehicle manufacturers, it does not require the devices.[125] If a manufacturer chooses to use a speed limiting device for compliance with that program, the speed limiting device must meet certain requirements. These requirements are not identical to the proposed FMVSS requirements. Specifically, the fuel efficiency program requirements permit speed limiting devices to have a soft top (i.e., a higher maximum speed than the set speed for a limited amount of time), which would not be permitted under the proposed FMVSS

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[125] See 40 CFR 1037.640.

requirements. The fuel efficiency program also specifies certain tamper-proofing requirements that would not be required by the proposed FMVSS. Finally, the proposed FMVSS includes a requirement that there be a means of reading the last two speed setting modifications and the time and date of those modifications, which is not required for speed limiting devices under the fuel efficiency program.

Although the proposed speed limiting device requirements are different than those for speed limiting devices under the fuel efficiency program, the requirements are not incompatible, and manufacturers would be able to design speed limiting devices that satisfy the requirements of the proposed FMVSS and the requirements necessary for the devices to be used for compliance with the fuel efficiency program. Manufacturers that choose to use speed limiting systems as a means of compliance with the fuel efficiency program would need to design a system that meets the requirements of both the program and the proposed FMVSS, i.e., a speed limiting system with an initial speed setting no greater than 65 mph that cannot be adjusted above the speed used for compliance under the fuel efficiency program. Although the proposed FMVSS would not prohibit a "soft top" feature, in order to meet the proposed requirements, the highest achievable speed using this feature would have to be initially set to a speed no greater than 65 mph.

6. Description of any significant alternatives to the rule which accomplish the stated objectives of applicable statutes and which minimize any significant economic impact of the proposed rule on small entities

The agencies examined the expected benefits and costs of alternative speed limiting requirements, including different maximum speed settings, various tamper resistance requirements, and alternative compliance test procedures. The agencies are also requesting comment on the potential alternative of tying set speed to the speed limit of the road using GPS, vision, or vehicle-to-infrastructure based technologies.

When speed limiters are required to set speeds at a particular speed, the requirement potentially imposes costs on CMV operators, including the small operators. A higher proposed speed setting would reduce the costs resulting from additional travel time. As explained in detail in the Unfunded Mandates Reform Act analysis below, NHTSA and FMCSA carefully explored the initial speed setting. The benefits estimate showed that limiting vehicles to a speed of 65 mph would save substantially more lives than the slightly higher speed setting of 68 mph. We also believe that 65 mph is an appropriate speed setting given the data on State speed limits and factory speed limiting device settings, which show that 65 mph is one of the most common maximum posted truck speed limit and is currently the most common speed limiting device setting for trucks. This speed setting would also harmonize U.S. requirements with those of Ontario and Quebec.

The agencies requests comment on how the rule will impact small businesses and alternatives that would accomplish the objectives of the rulemaking while minimizing the impacts to small businesses.

B. Unfunded Mandates Reform Act

The Unfunded Mandates Reform Act of 1995 (Public Law 104-4) requires agencies to prepare a written assessment of the costs, benefits, and other effects of proposed or final rules that include a Federal mandate likely to result in the expenditures by State, local or tribal governments, in the aggregate, or by the private sector, of more than $100 million annually (adjusted annually for inflation with base year of 1995). Adjusting this amount by the implicit gross domestic product price deflator for the year 2013 results in $141 million (107.128/75.861 = 1.41).[126] The assessment may be included in conjunction with other assessments, as it is here.

This proposed rule is not expected to result in the expenditure by State, local, or tribal governments, in the aggregate, of more than $141 million annually, but the proposed rule could result in the expenditure of that magnitude by the private sector. NHTSA's analysis indicates that although the proposed rule would result in minimal costs to vehicle manufacturers, it could result in expenditures by commercial vehicle operators. For example, with 65 mph speed limiters, the expenditures can $639 million annually, discounted at 7 percent. This is because limiting vehicles to speeds no greater than 65 mph will decrease the travel speed for heavy vehicles currently traveling faster than 65 mph, resulting in increased travel and delivery times.

The agencies have analyzed the expected benefits and costs of alternative speed limiting requirements, including different speed settings, various tamper resistance requirements, and

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[126] https://research.stlouisfed.org/fred2/series/GDPDEF/downloaddata

alternative compliance test procedures. The proposed speed setting is the requirement that potentially imposes costs on commercial vehicle operators.

The costs to operators increase as the set speed decreases due to increasing traveling times. However, these costs would be offset by the fuel savings associated with reduced travel speeds. Assuming that vehicle manufacturers design their speed limiting systems so that the systems also meet the necessary requirements to be used for compliance with the heavy vehicle fuel efficiency program (which the agencies expect they will), the fuel savings of this rule would be maximized at 65 mph because the fuel savings for speed limiting systems set below 65 mph were accounted for in the heavy vehicle fuel efficiency program final rule. This is because under the heavy vehicle fuel efficiency program, heavy vehicle drive cycles are tested at a maximum speed of 65 mph, and a speed limiting system with a setting at or above 65 mph will show no fuel savings. Thus, any fuel savings associated with speed settings of 65 mph and above were not estimated in the fuel efficiency program rulemaking.

However, fuel efficiency testing would reflect the difference in fuel savings between the 65 mph baseline and a speed limiting system with a set speed below 65 mph. Accordingly, because the difference in fuel savings between 65 mph and lower travel speeds as a result of speed limiting systems was accounted for in the heavy vehicle fuel efficiency program final rule, we are not including those savings in determining the effect of this rule and are only including the additional fuel savings from reducing travel speeds to 65 mph.

Comparing the costs and fuel savings of the various speed setting alternatives, which are discussed in detail in the PRIA, for example, the agencies estimate that limiting heavy vehicles to 68 mph would result in $209 million in societal costs (assuming a 7 percent discount rate) from increased travel times, as compared to $523 million in societal costs associated with limiting vehicles to 65 mph.   However, the $314 million cost difference ($523 million – $209 million (assuming a 7 percent discount rate)) would be offset by an additional $395 million in fuel savings that would be realized with a 65 mph speed setting ($712M) versus a 68 mph speed setting ($317M.

On the other hand, the agencies estimate that limiting heavy vehicles to 60 mph would result in $1.6 billion in costs (assuming a 7 percent discount rate) from increased travel times, i.e., an increase in costs of $1.1 billion compared to the costs of a 65 mph speed setting. However, as explained above, assuming that vehicle manufacturers design their speed limiting systems so that the systems also meet the necessary requirements to be used for compliance with the heavy-duty vehicle fuel efficiency program, no additional fuel savings from limiting vehicles to 60 mph versus 65 mph could be attributed to this rulemaking without double counting the benefits already accounted for in the medium- and heavy-duty vehicle fuel efficiency program rulemaking.

When the costs were subtracted from the fuel savings, therefore, we believe that a 65 mph speed limiting device would be the best theoretical alternative when compared to 60 mph and 68 mph speed limiting devices.

VIII. UNCERTAINTY ANALYSIS

This chapter identifies and quantifies the major uncertainties in the cost-effectiveness and net benefit (benefit-cost) analyses. Throughout the course of both the cost-effectiveness and net benefit analyses, many assumptions were made, diverse data sources were used, and different statistical processes were applied. The variability of these assumptions, data sources, and statistical processes potentially would impact the estimated regulatory outcomes. These assumptions, data sources, and derived statistics all can be considered as uncertainty factors for the regulatory analysis. Typically, the uncertainty analysis is conducted to identify the uncertainty factors with appreciable variability and quantify them by their probability distributions. [127]

The analysis starts by establishing mathematical models that imitate the actual processes in deriving cost-effectiveness and net benefits, as shown in previous chapters. Each variable in the mathematical models represents an uncertainty factor that would potentially alter the model outcomes if its value were changed. Variations of these uncertainty factors are described by

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[127] Typically, values from these distributions are randomly selected and fed back to the cost-effectiveness and net benefit analysis process using the Monte Carlo statistical simulation technique. Robert, C.P. & Casella, G., *Monte Carlo Statistical Methods*, Springer-Verlag New York, Inc., 999 b: Liu, J.S., *Monte Carlo Strategies in Scientific Computing*, Springer-Verlag New York, Inc., 2001 (Or any statistics books describing the Monte Carlo simulation theory are good references for understanding the technique.)

appropriate probability distribution functions based on available data. If data are not sufficient or not available, professional judgments are used to estimate the distribution of these uncertainty factors.

Models:

Models were built to imitate the process used in deriving net benefits as developed in previous chapters. The net benefit model is comprised of two principal components: benefits and costs. As shown in the net benefit chapter, the proposed rule would be cost effectiveness with the crash prevention, projected fuel savings, and GHG savings. The analysis presents and summarizes the results for net benefits among combination trucks (CT).

Benefit Components:

As described earlier, this analysis considers only combination trucks (CTs). The benefits are composed of the following categories:

Fuel savings

Green-house gas (GHG) savings

Safety benefits (reduction in injury severity)

Societal economic injury savings

Property damage savings

<u>Fuel savings:</u>

For the FARS & GES method, as discussed in the benefit chapter, we examined crashes by a posted speed limit of 55, 60, 65, 70 and 75 mph, where the crashes were based on GES data. For each posted speed limit, then, the number of crashes distributed by the travel speed for the road to determine the number of crashes at a given travel speed. The number of crashes with respect to the travel speed was used as a proxy for the road use traveled by a particular vehicle type (for example, combination trucks).

The number of crashes or target population, P, is important to the fuel saving estimates because the exposure rate was derived from it. The major uncertainties in this factor arise from sources such as demographic projections, driver/occupant behavioral changes (with a speed limiting device), increased roadway travel, new Government safety regulations, and survey errors in NHTSA’s data sampling system NASS-GES.

The impact of demographic and driver/occupant behavior changes, roadway traveling, and new automobile safety regulations are reflected in the crash database. Thus, the analysis examined the historic FARS and GES to determine whether variations resulting from these uncertainty sources would warrant further adjustment to the future target population. Based on 2004 to 2013 FARS, there is no definite trend for this period of time. The changes among years were small. Data from 2004-2013 GES yields a similar result. Therefore, the analysis does not further adjust the target population to account for variations associated with these uncertainty sources. Only survey errors from GES are considered here. The size of the target population is treated as normally distributed. Survey errors for GES are used as the proxy for standard deviation to establish the normal distribution. Generally, about 68 percent of the estimated target population is within one standard error (SE) of the mean survey population. The standard errors were derived using the formula[128]:

$$SE = e^{a + b(\ln x)^2}, \text{ where}$$

$a = 4.310860$

$b = 0.035690$

x = estimated target injuries.

To determine the fuel saving with a certain level of probability, the number of GES estimated crashes at each posted speed limit was normally distributed with the standard deviation. For example, according to GES data, there were 35,643 crashes on roads with a posted speed limit of 55 mph. With the formula above, the standard deviation was estimated to be 3,758.

Similarly, the same distribution was applied to crashes with speeds of 60,65, 70, and 75+mph. Together, the sum of crashes for those speed limits is 139,812.

As discussed in the benefit chapter, in general, fuel efficiency increases as travel speed decreases. Therefore, when the number of vehicles on roads with lower travel speed increases, the overall fuel efficiency increases.

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[128] NHTSA Traffic Safety Facts, 2009, http://www-nrd.nhtsa.dot.gov/Pubs/811402.pdf

<u>GHG saving:</u>

In the benefit chapter, for the estimated 304 million gallons of fuel saving for combination trucks, the GHG saving was estimated to be $186 million. In other words, for every gallon of fuel saved, GHG saving would be $0.61 ($186/304 gal = $0.61/gal) in 2013 dollars. For estimating the net benefits, GHG saving was translated into dollars. The GHG benefit in the net benefit calculation is equal to FS*GM where GM equals the GHG saving per a gallon of diesel fuel saved. For the analysis, we assumed that GM is constant, as shown above.

GHG = FS * GM (where GM = $0.61/gal)

<u>Cumulative lifetime discount factors (D):</u> represent the present discount factor over the vehicle's life. These factors are derived based on the agency study on vehicle miles traveled and vehicle survivability[129]. Variation of these factors comes from vehicle mileage surveys, national vehicle population, and statistical process. These uncertainties cannot be quantified at this time. Thus, the analysis treats these ratios as constants.

<u>Crash Benefits (Safety benefit, Societal economic injury savings, Property damage savings)</u>

This analysis anticipates with decreased speed, there will be decreased injury severity in the resultant crashes. This is not assuming so much that crashes will not occur. It simply assumes

[129] Vehicle Survivability and Travel Mileage Schedules, Technical Report, DOT HS 809 952, January 2006 (Docket No. 22223-2218)

that when they do occur, there will be less kinetic energy in the participants of a collision and therefore less force will be applied to the vehicles and the human bodies within.

Cost Components:

The following is a list of cost components:

Equipment cost

Opportunity lost cost

Inventory cost

Cost to hire new drivers

When the final summary numbers are presented, they will present the appropriate selection of the above costs. For clarity, we note that the costs here while dealing with the economic implications for the fleet or for drivers, a sum of all costs does not reflect the fuel savings or greenhouse gas savings expected, as those are counted as benefits rather than as "negative economic costs."

Equipment Cost

As there is no physical countermeasure to add, there is no equipment cost for this rule.

Opportunity Lost Cost

Drivers that otherwise would be going home or performing other jobs will take a longer amount of time to complete their routes. The loss of the opportunity to do anything other than driving additional hours is monetized and presented in dollars. This assumes that the amount of money earned for traversing the same route remains the same, and simply requires more time. (For additional discussion, see Scenario 1 in the cost chapter.) But that time has value to the drivers, and an estimate of its worth, in dollars, is presented.

Inventory Cost:

Due to longer trip times, the additional cost of transporting goods over longer periods of time has to be monetized.

Cost to hire new drivers:

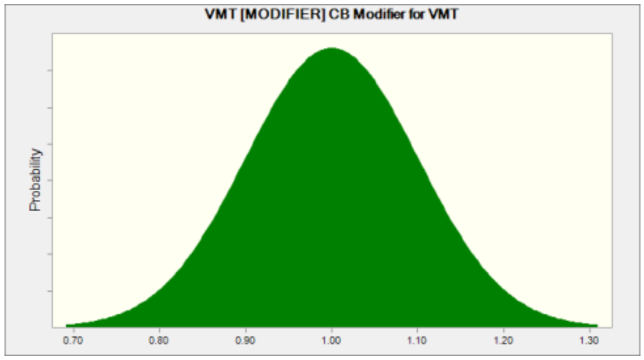
Trucking companies, given the longer trips, may hire additional drivers to perform their current routes, lengthened in trip time by the rule. (For additional discussion, see Scenario 2 in the costs chapter.) An estimate of these costs is provided.

Quantifying the Uncertainty Factors:

This section establishes the appropriate probability distributions for uncertainty factors that come with applicable variations including target population and quantifies the constant values for other factors. Using Crystal Ball to perform a Monte Carlo analysis, certain elements are changed from single values to distributions, and the choice of distribution type and corresponding parameters is important in ensuring a meaningful result. The following is the list of variables in our model, their distribution, and our reasoning behind the choice.

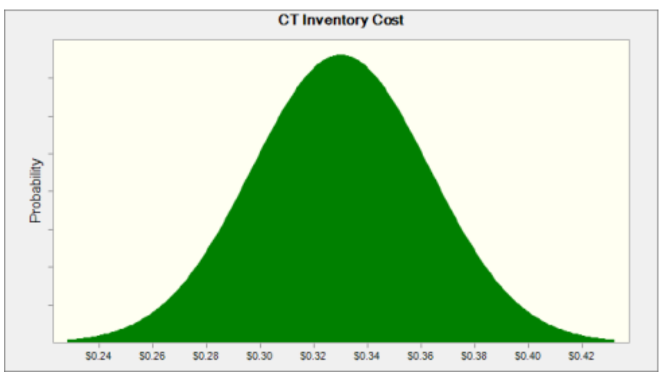
VMT

Vehicle Miles Traveled (VMT) represents the basis of both cost and benefit estimates, and in the absence of statistical input from the data source authors, a normal distribution with a mean of the value used in the main analysis (48,022) and a standard deviation of 10% of that mean value was used.[130]



Inventory Cost

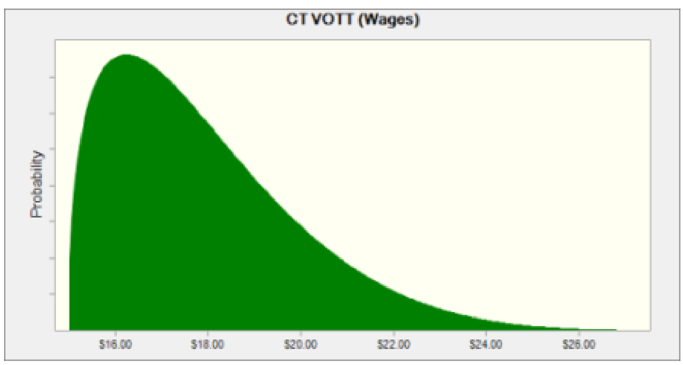
Inventory cost applies exclusively to the inventory cost component, and is a proportionately small portion of the overall costs. In the absence of statistical input from the data source authors, a normal distribution with a mean of the value used in the main analysis and a standard deviation of 10% of that mean value was used.



Value of Travel Time (VOTT)

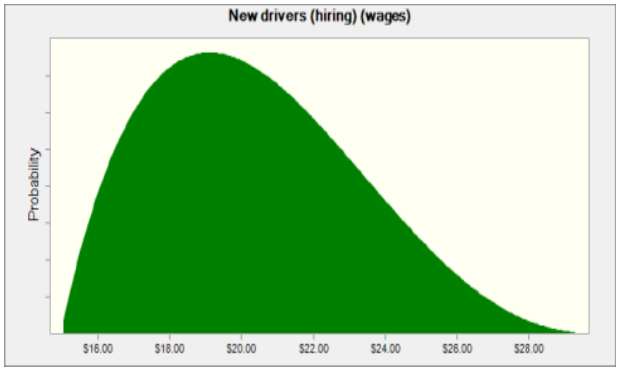
130 [Note: due to the construction of the internal model, a multiplicative factor was used, and its distribution is seen in the chart below]

As the primary of the opportunity cost component for drivers, this variable has a value of $17.50/hr in the main analysis, as recommended by the DOT guidance. However, some drivers would value their time higher than $17.50/hr. As a result, alternate interpretations of the value of driver time resulted in a value nearly twice that, for the 90th percentile of values. Complicating matters was the fact that the first methodology provided a mean of $17.50, but the other estimate only provided costs at 50th, 75th and 90th percentile. (For additional discussion, see the costs chapter.) Furthermore, a floor of $15 was estimated to be the absolute minimum value for the monetary equivalent of a licensed driver's time. To combine all of this information in a meaningful way, a beta distribution was used, with minimum $15, 50th percentile of $17.50, a maximum of $30, and a Beta value of 6.



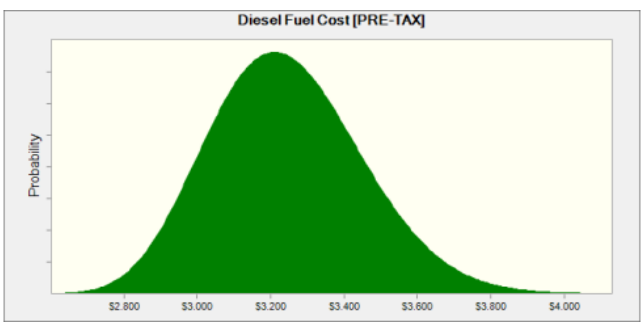
New drivers (hiring)

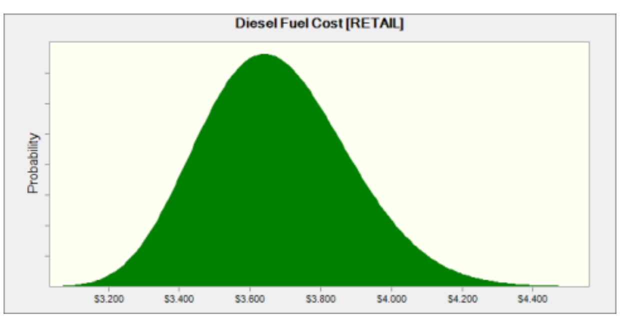
Similar to the VOTT (opportunity costs) above, these fleet-level costs were adapted to have a beta distribution with minimum wages of $15, a maximum wage of $30, a median wage of $20.08 (as used in the main analysis), and a Beta value of 3.5 to qualitatively approximate a normal distribution.

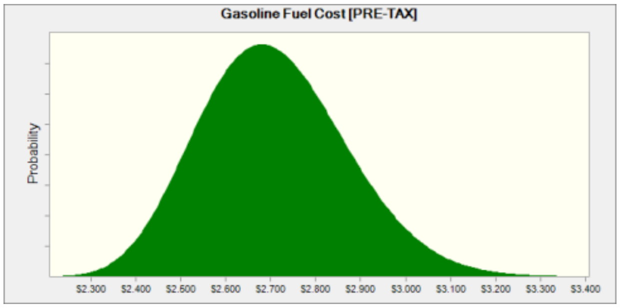


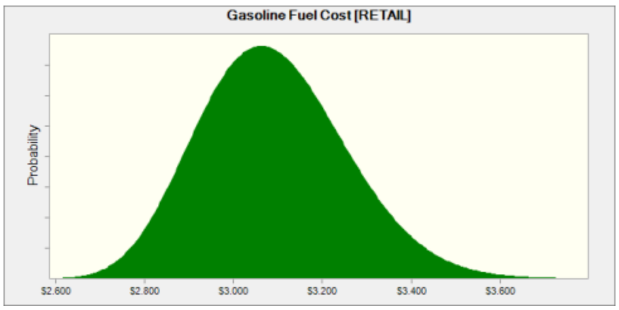
Fuel Costs (Diesel and Gasoline, Pre-tax and Retail)

Fuel costs come in four different types. Diesel Pre-tax costs, Diesel Retail costs, Motor Gasoline Pre-tax costs, and Motor Gasoline Retail costs. The source of the data is the Annual Energy Outlook (AEO), and while the values in the main analysis are the AEO's primary estimate for fuel costs, the AEO also provides a "high oil price" and "low oil price," which express some sort of bound on the AEO's expectation on petroleum pricing. Without any additional guidance on the likelihood of these events, a beta distribution was chosen, using their primary value as the median, and the lower and upper bound as the maximum, and a beta of 30 in all four cases.





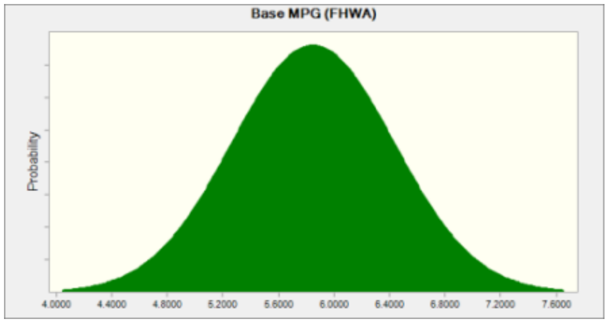




	Diesel Pre-Tax	Diesel Retail	Gas Pre-Tax	Gas Retail
Minimum	$2.387	$2.818	$2.049	$2.427
Maximum	$5.392	$5.821	$4.418	$4.818
50%	$3.233	$3.663	$2.699	$3.081
Beta	30	30	30	30

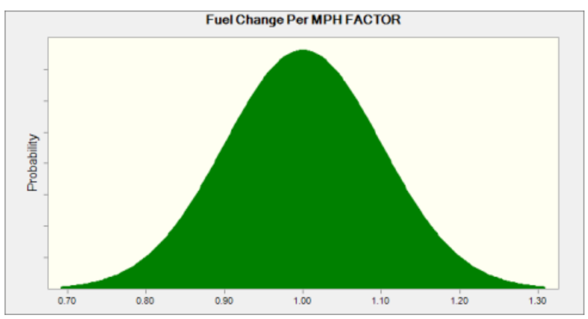
<u>Miles Per Gallon (MPG)</u>

There's some uncertainty over how many miles are traveled for every gallon of fuel spent. FHWA data results in an estimate of 5.85 mpg. In the absence of statistical input from the data source authors, a normal distribution with a mean of the value used in the main analysis and a standard deviation of 10% of that mean value was used.



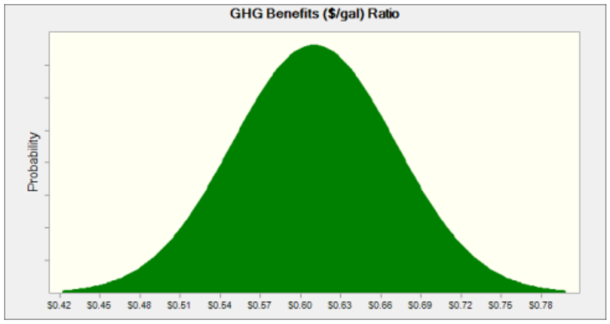
Incremental Fuel Use at higher speeds

As a vehicle drives at higher and higher speeds, the amount of extra fuel needed to go 1mph faster increases. It is assumed that an increase in the operating speed of 1mph decreases fuel economy by 1.37%. In the absence of statistical input from the data source authors, a normal distribution with a mean of the value used in the main analysis and a standard deviation of 10% of that mean value was used.



Greenhouse Gas (GHG) Benefits

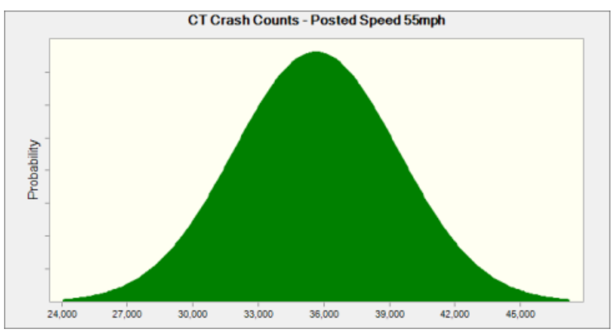
When vehicles drive at slower speeds to cover the same distance, less fuel is burned. As a result, less greenhouse gases are emitted into the atmosphere. In the absence of statistical input from the data source authors, a normal distribution with a mean of the value used in the main analysis and a standard deviation of 10% of that mean value was used.

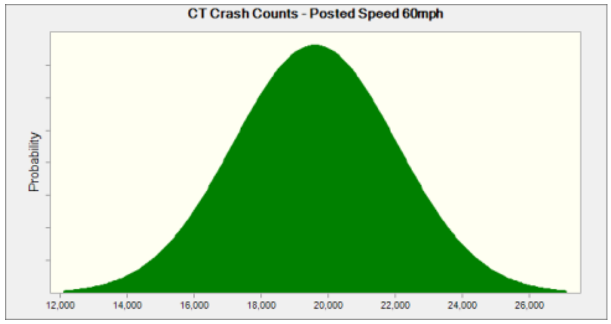


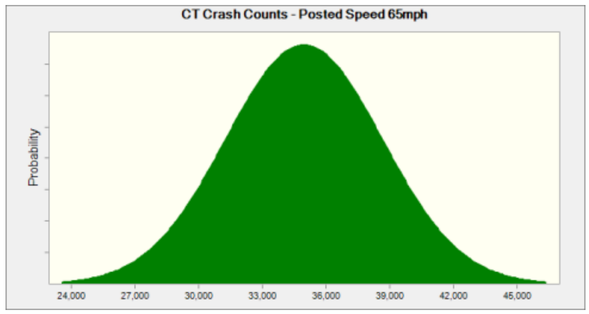
<u>Crash counts</u>

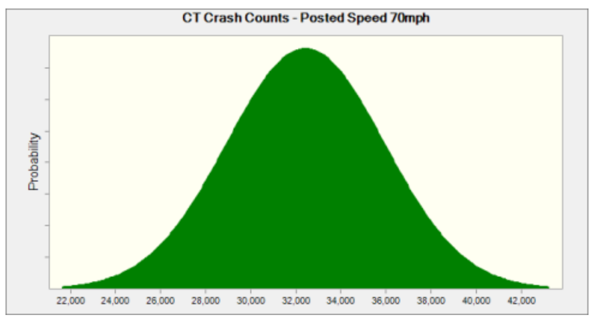
Crash counts were used to determine the distribution of vehicle highway travel speeds with respect to posted speed limits. This distribution itself is a 5-part estimate based upon GES data for the different posted speed limits at and above 55mph. The standard error for GES (as described by the equation above was used, and thus all of these variables were simulated using a mean of their value from the report and a standard deviation as determined by the equation.

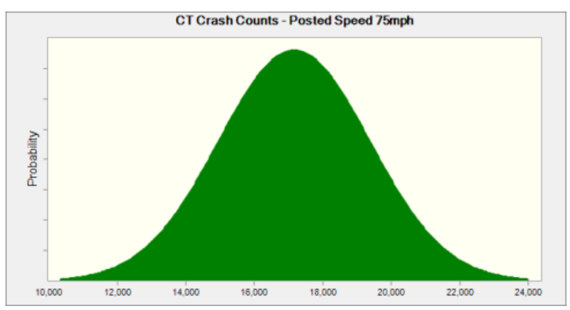
Posted Speed Limit	Original Value	Standard Error
55	35,643	3,758
60	19,613	2,435
65	34,957	3,704
70	32,433	3,503
75	17,166	2,217





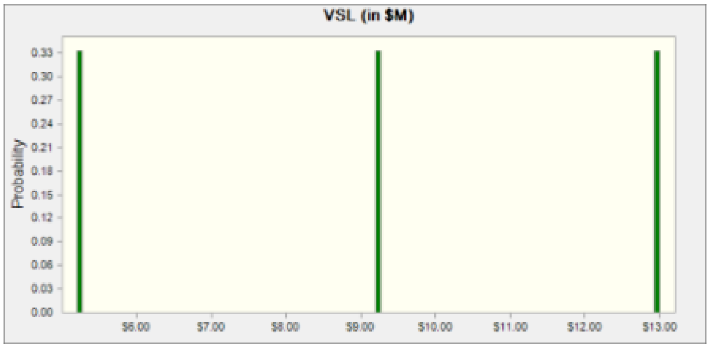






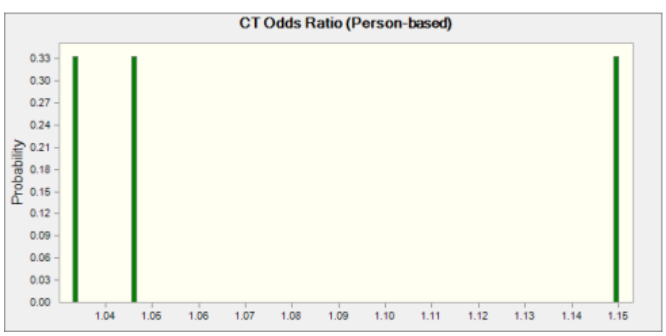
Value of a Statistical Life (VSL)

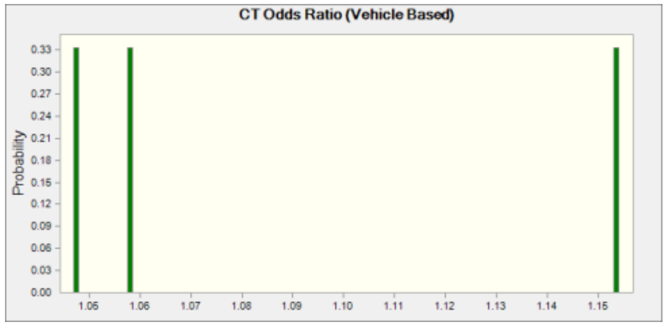
The value of a statistical life (VSL) is used to monetize potential safety benefits from fatalities and injuries. The value of the VSL can vary depending on one's interpretations and assumptions, and traditionally in cost-benefit analyses, the agency uses a core value for the main analysis and provides a sensitivity analysis later exploring the impact of valuing a statistical life with a different amount. The current agency recommendations for VSL are a main value of $9.2M per life saved, with a lower value of $5.2M per life saved and an upper value of $13.0M per life saved, all in 2013 economics. Instead of presenting a separate uncertainty analysis for each value, or a sensitivity on uncertainty results, we have simply included these various interpretations in our uncertainty analysis.



<u>Odds Ratio (Person based and Vehicle based Approaches)</u>

As we will discover later, this variable is a key indicator of the results for net benefits. The two different types of odds ratios are presented in the main analysis, but each one actually came from a set of three candidates from various alternate interpretations. As all of these interpretations were equally valid and internally consistent, the uncertainty analysis provided a discrete distribution in which each of the three options was equally likely to be picked. Thus, the Person-based Odds Ratio was distributed discretely across {1.033, 1.046, 1.150} and the Vehicle-based Odds Ratio was distributed discretely across {1.047, 1.058, 1.154}.





Net Benefit Model

After all of the component benefits and costs were calculated, they were combined to present the following summary values.

Net Benefit = (Safety benefits + Fuel Savings [pre-taxed] + GHG Savings + Societal Economic Injury Savings + Property Damage Savings) – (Opportunity Lost Cost + Inventory Cost)

Fleet Net Benefit = (Fuel Savings[after tax]) – (Cost to hire new drivers + Inventory Cost)

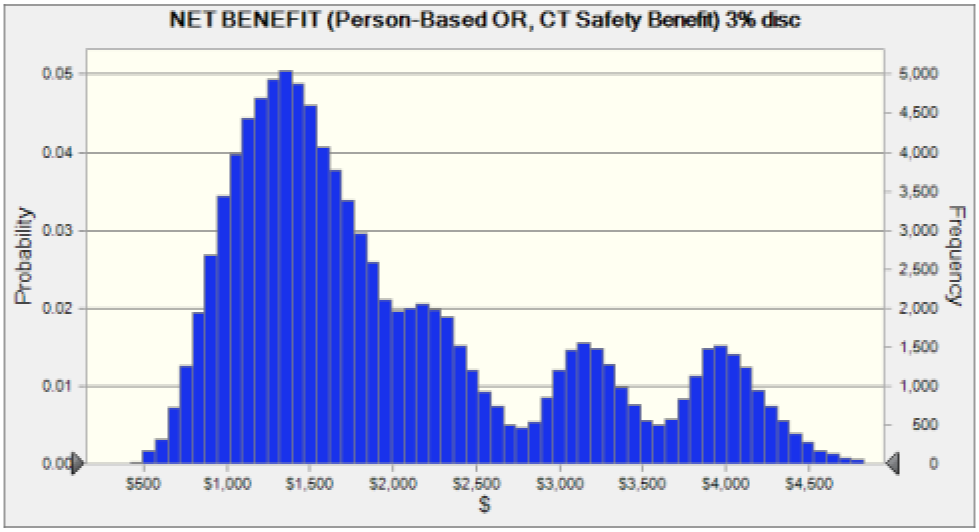
Owner-operator's Perspective = Fuel Savings [after tax] – (Opportunity Cost + Inventory Cost)

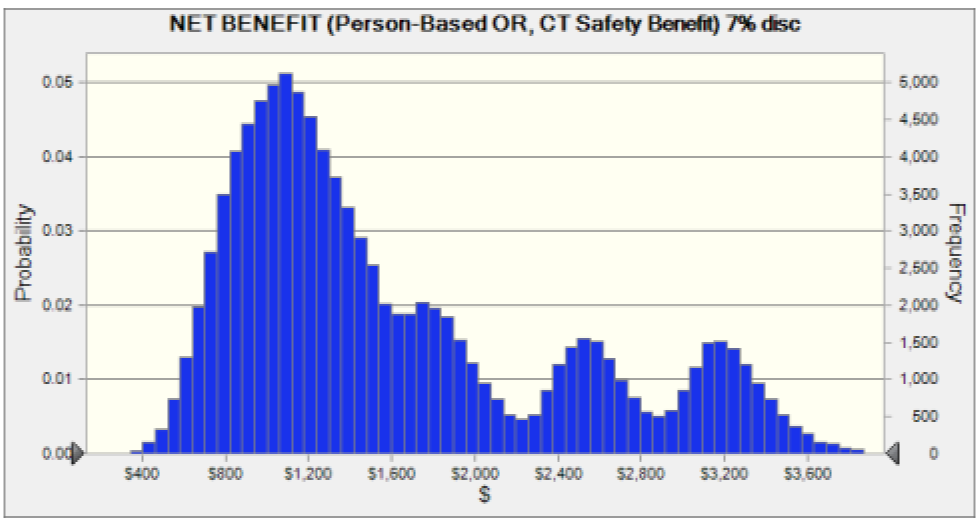
Several variables in the analysis were presented separately rather than being simulated. The values presented separately include a lower and upper bound on benefits (driven by choosing person-based or vehicle-based odds ratio methodology).

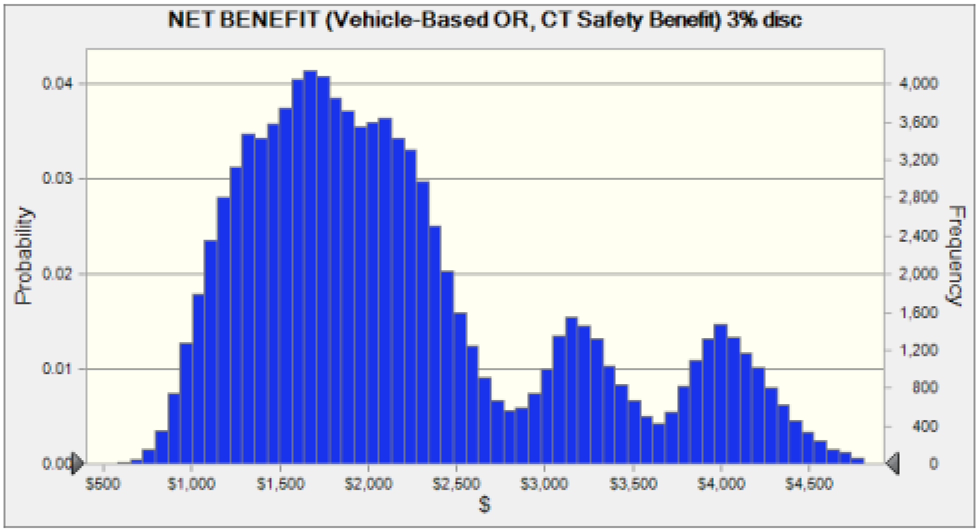
Therefore, the three summary values described above will be presented with the appropriate alternative presentations. In addition, for Net Benefits, the value of the safety benefit varies, and thus net benefits are presented with both Lower Bound and Upper Bound Safety Benefits.

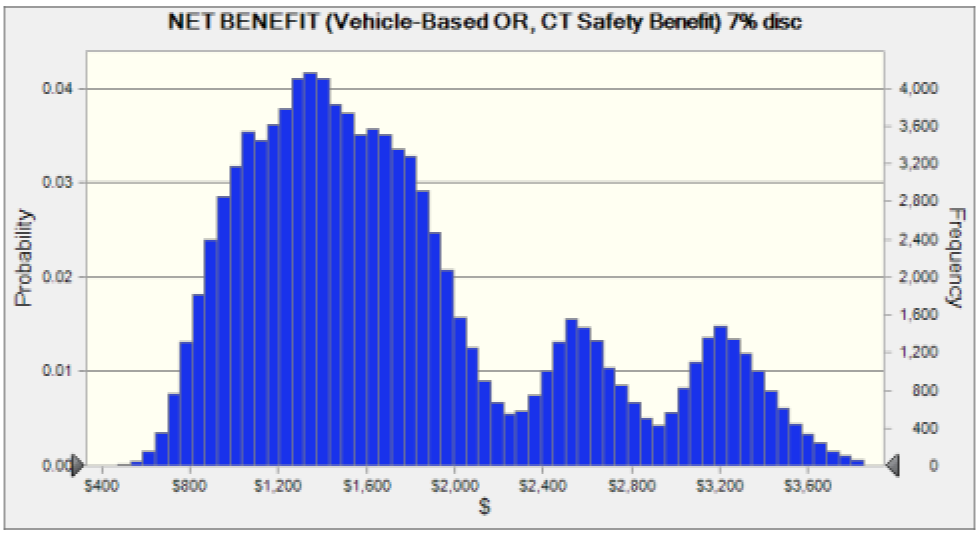
<u>Net Benefits</u>

Net benefits has nine clusters of values, several of which sit on top of each other. The smaller group on the right represents the higher odds ratio value, for three different values of VSL. The larger jagged peak on the left is a combination of 6 smaller peaks, the product of the two other odds ratios and three VSL values. The following four tables present the result of the uncertainty analysis for net benefits, considering the lower and upper safety benefits across the 3 and 7 percent discount factor.



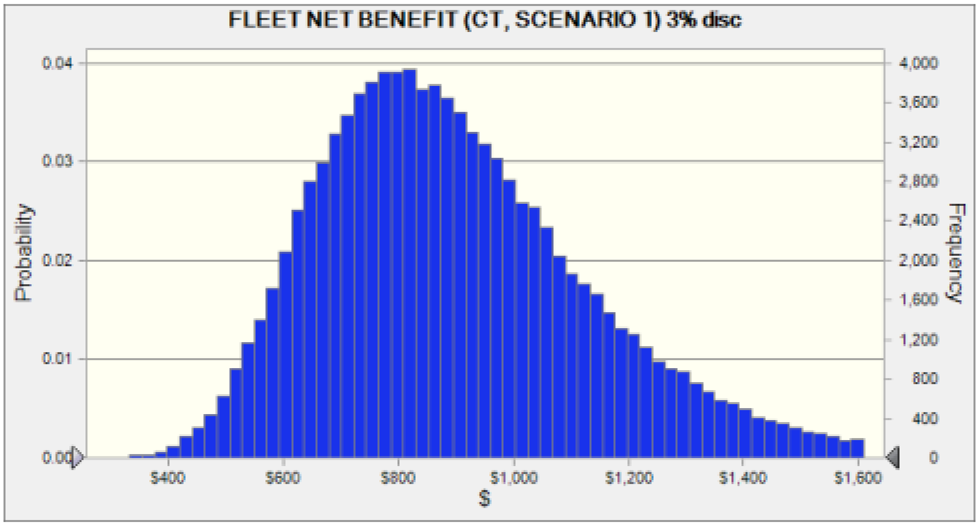


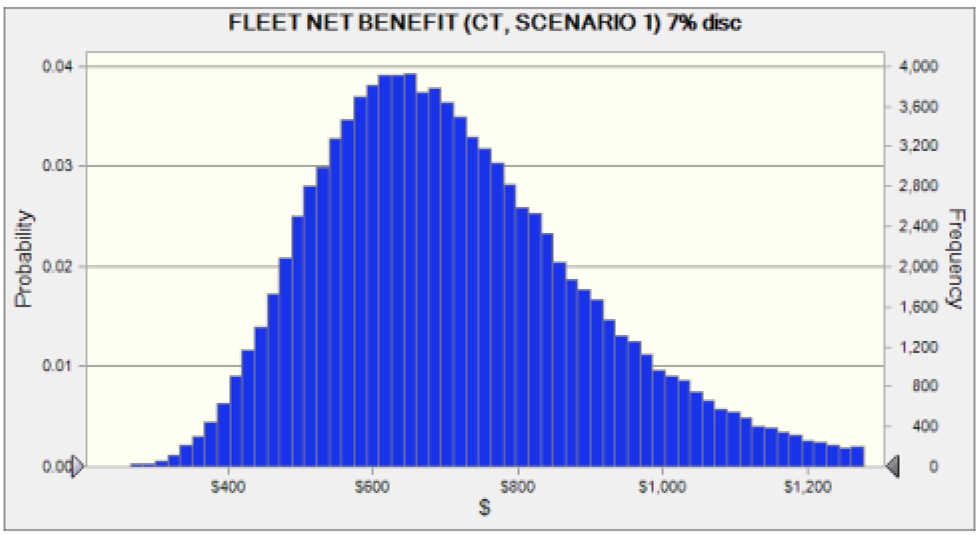


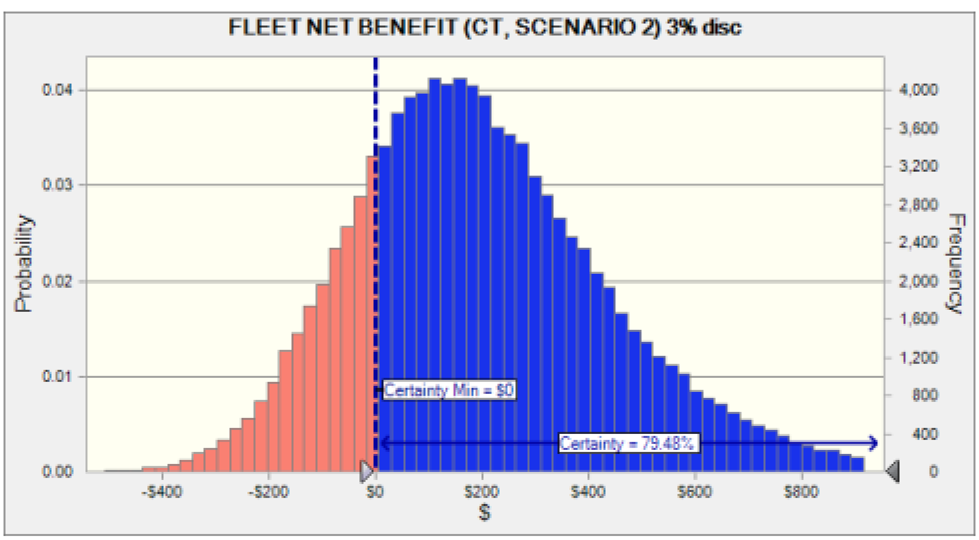


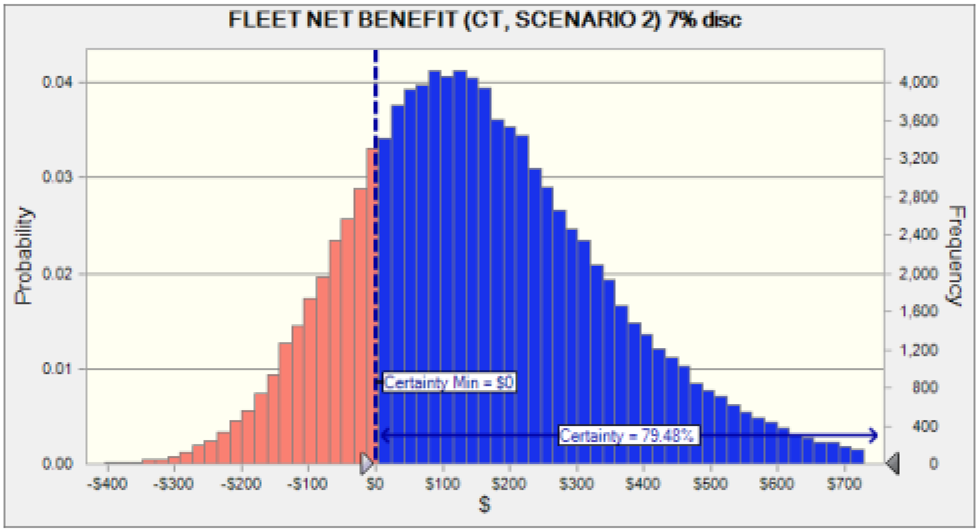
<u>Fleet Net Benefits</u>

Contrasting with the Net Benefits, Fleet Net Benefits has a more familiar single slope of results. They are presented below, for Scenario 1 and Scenario 2, across the 3 and 7 percent discount rates. Also, in both charts for Scenario 2, it shows that nearly 88% certainty that a 65 mph speed limiter requirement would have a positive net benefit.


FLEET NET BENEFIT (CT, SCENARIO 1) 3% disc
Probability
Frequency
$

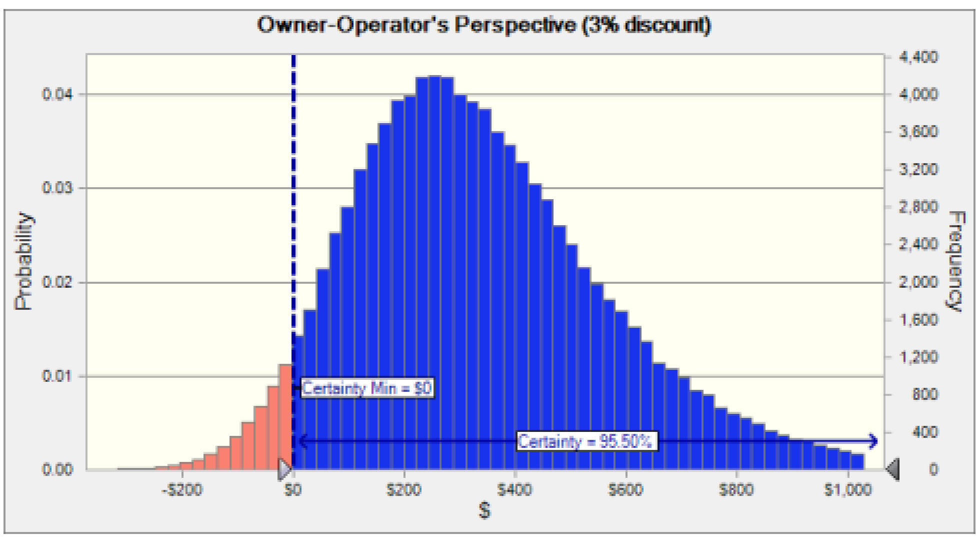

FLEET NET BENEFIT (CT, SCENARIO 1) 7% disc
Probability
Frequency
$

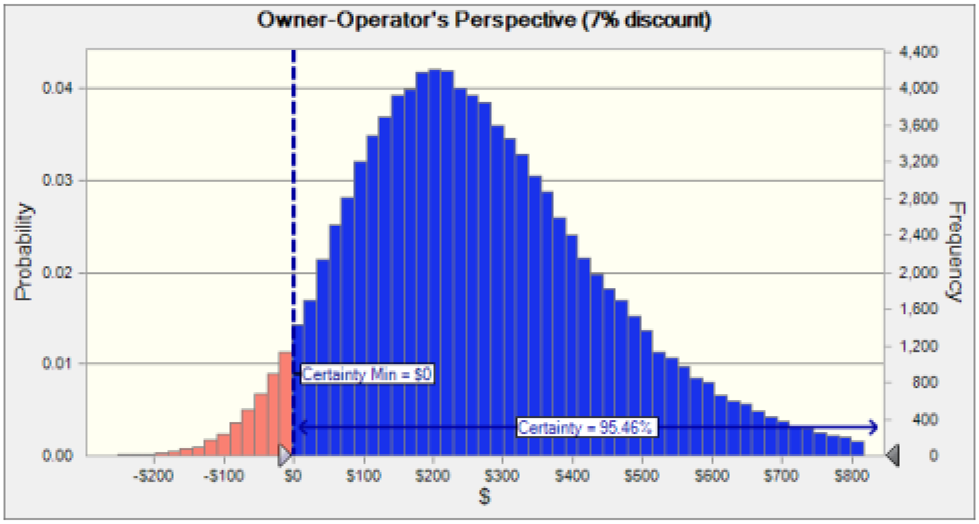

FLEET NET BENEFIT (CT, SCENARIO 2) 3% disc
Probability
Frequency
Certainty Min = $0
Certainty = 79.48%
$



Owner-Operator's Perspective

From a truck driver's perspective, especially for owner-operators, we took the opportunity cost for the driver's prerogative, the after-tax money they will save on fuel to perform the same routes, and the added inventory cost to keep their cargo in transit for longer periods of time. Note that there is a greater than 99.26 percent certainty that these impacts are a net positive. Only in a fraction of a percent of simulations resulted in a negative impact from the driver's perspective.





Conclusion

The uncertainty analysis shows that requiring a 65 mph speed limiter for combination trucks the proposed rule has a 100% chance of a positive net benefit, an 88% chance of a positive Fleet net benefit, and a 99% chance of a positive benefit from the owner-operator's perspective.

Appendices

Appendix A Summary of lives saved and injuries prevented, 65 mph speed limiters

Single Variable Model

In addition to the multivariable regression models, we considered a single variable model, as discussed in the following section.

Single variable vehicle-based model using speed distribution for combination trucks,:

In addition to the vehicle-based model with multiple variables (using the speed distribution and the mean speed), we conducted a vehicle-based single variable logistic regression with the combination truck speed distribution. The results of the modeling show that the risk of fatal crash would increase by 1.058 when the speed of a combination truck is increased by one mile per hour (mph). The 1.058 odds ratio is statistically significant with a p-value <5%.

Combination trucks, single variable vehicle-based modeling with travel speed distribution, Maximum Likelihood Estimates for each mile interval

Analysis of Maximum Likelihood Estimates					
Parameter	**DF**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Intercept	1	-6.9831	1.0532	43.9630	<.0001
Higher speed (1)	1	0.0565	0.0160	12.4110	0.0004

Combination trucks, single variable vehicle-based modeling with travel speed distribution, Odds Ratio Estimates, for each mile interval

Odds Ratio Estimates			
Effect	**Point Estimate**	**95% Wald Confidence Limits**	
Higher speed (1)	1.058*	1.025	1.092

*The odds ratio is significant with p-value under 5%.

Combination trucks, single variable person-based model, with a speed distribution:

In addition to the person-based model with multiple variables (using the speed distribution and the mean speed), we conducted a vehicle-based single variable logistic regression with the combination truck speed distribution. The results of the modeling show that the risk of fatality would increase by 1.046 when the speed of a combination truck is increased by one mile per hour (mph). The 1.046 odds ratio is statistically significant with p-value <5%.

Combination trucks, person-based single variable model with travel speed distribution, Maximum Likelihood Estimates, for each mile interval

Analysis of Maximum Likelihood Estimates			
Estimate	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
-7.1479	1.7194	17.2825	<.0001
0.0446	0.0220	4.1260	0.0422

Combination trucks, person-based single variable model with travel speed distribution, Odds Ratio Estimates, for each mile interval

Odds Ratio Estimates			
Effect	**Point Estimate**	**95% Wald Confidence Limits**	
Higher speed (1)	1.046*	1.002	1.092

<u>SUTs, single variable vehicle-based model with speed distribution :</u>

We conducted a vehicle based single variable (i.e., speed) logistic regression with the single unit truck travel speed distribution. The vehicle-based model indicated that 5.3% higher risk is associated with higher travel speed.

SUTs, single variable **vehicle-based** modeling with distribution travel speeds, Maximum Likelihood Estimates for each mile interval

Analysis of Maximum Likelihood Estimates					
Parameter	**DF**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**

Analysis of Maximum Likelihood Estimates					
Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	-7.5437	1.4381	27.5157	<.0001
Speed	1	0.0515	0.0217	5.6263	0.0177

SUTs, single variable **vehicle-based** modeling with travel speed distribution, Odds Ratio Estimates, for each mile interval

Odds Ratio Estimates			
Effect	Point Estimate	95% Wald Confidence Limits	
Higher speed (1)	1.053*	1.009	1.099

* Statistically significant

Interpretations: This analysis produced a significant comparison between lower and higher speed fatalities, (i.e., OR = 1.053 with a p-value of 0.0177).

The results of the modeling, from occupant-based model, show that the risk of fatality would increase by 1.068 when the speed of a SUT is increased by one mile per hour (mph).

SUTs, **person-based** single variable model with travel speed distribution, Maximum Likelihood Estimates, for each mile interval

Analysis of Maximum Likelihood Estimates					
Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	-9.5834	1.6620	33.2484	<.0001
Higher speed (1)	1	0.0658	0.0197	11.2008	0.0008

SUTs, **person-based** single variable model with travel speed distribution, Odds Ratio Estimates, for each mile interval

Odds Ratio Estimates			
Effect	Point Estimate	95% Wald Confidence Limits	
Higher speed (1)4	1.068*	1.028	1.110

Bus single variable vehicle-based model with speed distribution:

We conducted a vehicle based single variable (i.e., speed) logistic regression with the bus travel speed distribution. The results show that the risk of fatality would increase by 1.120 when the speed of a bus is increased by one mile per hour (mph).

Bus single variable (VAR) **vehicle-based** 1-VAR model with travel speed distribution, Maximum Likelihood Estimates for each mile interval

Analysis of Maximum Likelihood Estimates					
Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	-11.1503	2.5024	19.8552	<.0001
Travel speed	1	0.0934	0.0354	6.9783	0.0083

Odds Ratio Estimates

Odds Ratio Estimates of Bus, Distribution			
Effect	Point Estimate	95% Wald Confidence Limits	
Higher Speed (1)	1.120	0.989	1.268

The results of the modeling, from occupant-based model, show that the risk of fatality would increase by 1.098 when the speed of a BUS is increased by one mile per hour (mph).

Bus single variable **person-based** model with travel speed distribution, Odds Ratio Estimates, for each mile interval

Analysis of Maximum Likelihood Estimates					
Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	-11.1503	2.5024	19.8552	<.0001
speed	1	0.0934	0.0354	6.9783	0.0083

Odds Ratio Estimates

Odds Ratio Estimates, 1 VAR

Effect	Point Estimate	95% Wald Confidence Limits	
Higher speed (1)	1.098*	1.024	1.177

Summary of Effectiveness

In summary, the odds ratio from the person-based model for CT's ranges was estimated to range from 1.028 to 1.155 for each mile derived with two different approaches. In addition, the odds ratio was estimated to be 1.035 to 1.097 for SUTs. For buses, the odds ratio was estimated to range 1.024 to 1.165. The odds ratios from the person-based model are summarized below.

Illustration of 'Occupant-based' Odds Ratios for Combination Trucks, SUTs and Buses

Vehicle Type	With speed distribution, for each mile		With mean speed, for each mile		Speed distribution, single variable
	Without belt use adjustment	With belt use adjustment	Without belt use adjustment	With belt use adjustment	One variable: Speed
Comb. Truck	1.033*	1.026	1.155*	1.150*	1.046*
SUT	n/a	1.035	n/a	1.097	1.068*
BUS	n/a	1.024	n/a	1.165	1.098*

* Statistically significant,

Summary of All Models, lives saved and injuries prevented, 65 mph speed limiters

Summary of Overall Odds Ratio Considered (Vehicle or Occupant Based)

Vehicle	Approach	Speed Data and Variables used		
		Speed distribution, multivariable	Mean speed, multivariable	Speed distribution, single variable
CT	Vehicle-based	1.047*	1.154*	1.058*
	Person-based†	1.033*	1.150*	1.046*
SUT	Vehicle-based	1.014	1.079	1.053
	Person-based‡	1.035	1.097	1.068*
BUS	Vehicle-based	0.996	1.081	1.12
	Person-based‡	1.024	1.165	1.098*

* Statistically significant; † With unadjusted belt use rate; ‡ With adjusted belt use rate

Annual Number of Lives Saved for Combination Truck, 65 mph speed limiters

	Person-based			Vehicle-based		
	multivariab	multivariable,	single	multivariable,	single	multivariable,

	le, speed distribution	mean speed	variable, speed distribution	speed distribution	variable, speed distribution	mean speed
Odds Ratio	1.033	1.150	1.046	1.047	1.058	1.154
Lives saved	62	201	83	84	100	204
MAIS 1	1,134	3,683	1,516	1,536	1,831	3,728
MAIS 2	148	481	198	201	239	487
MAIS 3	57	185	76	77	92	188
MAIS 4	8	25	10	10	12	25
MAIS 5	4	12	5	5	6	12

Annual Number of Lives Saved for SUTs, 65 mph speed limiters

	Person-based			Vehicle-based		
	multivariable, speed distribution	multivariable, mean speed	single variable, speed distribution	multivariable, speed distribution	single variable, speed distribution	multivariable, mean speed
Odds Ratio	1.035	1.097	1.068*	1.014	1.079	1.053
Lives saved	**2**	5	4	**1**	4	3
MAIS 1	37	86	65	15	72	52
MAIS 2	5	11	8	2	9	7
MAIS 3	2	4	3	1	4	3
MAIS 4	0	1	0	0	0	0
MAIS 5	0	0	0	0	0	0

Annual Number of Lives Saved for Buses, 65 mph speed limiters

	Person-based			Vehicle-based		
	multivariable, speed distribution	multivariable, mean speed	single variable, speed distribution	multivariable, speed distribution	single variable, speed distribution	multivariable, mean speed
Odds Ratio	1.024	1.165	1.098*	1	1.081	1.12
Lives saved	**1**	5	4	**0**	3	4
MAIS 1	20	94	66	0	54	71
MAIS 2	3	12	9	0	7	9
MAIS 3	1	5	3	0	3	4
MAIS 4	0	1	0	0	0	0
MAIS 5	0	0	0	0	0	0

Combination trucks

CT

Odds Ratio:	1.047		Vehicle-based logit		
Speed Limiter Set at		60 mph	65 mph	68 mph	70 mph

Lives saved	213	84	36	18
Major injuries* prevented	236	92	40	19
minor injuries prevented	4,419	1,737	750	366
PDO crashes affected	12,848	5,067	2,172	1,086

* Major injuries: MAIS 3, 4, 5. Minor injuries: MAIS 1, 2

CT

Odds Ratio:	1.033	Person-based logit		
Speed Limiter Set at	60 mph	65 mph	68 mph	70 mph
Lives saved	159	62	27	13
Major injuries prevented	176	69	30	15
minor injuries prevented	3,302	1,282	553	270
PDO crashes affected	9,591	3,740	1,629	784

CT

Odds Ratio:	1.058	Vehicle-based logit		
Speed Limiter Set at	60 mph	65 mph	68 mph	70 mph
Lives saved	251	100	43	21
Major injuries prevented	278	110	48	24
minor injuries prevented	5,208	2,070	899	441
PDO crashes affected	15,140	6,032	2,594	1,267

CT

Odds Ratio:	1.046	Person-based logit		
Speed Limiter Set at	60 mph	65 mph	68 mph	70 mph
Lives saved	210	83	36	18
Major injuries prevented	232	91	39	19
minor injuries prevented	4,348	1,714	743	365
PDO crashes affected	12,667	5,007	2,172	1,086

CT

Odds Ratio:	1.154	Vehicle-based logit		
Speed Limiter Set at	60 mph	65 mph	68 mph	70 mph
Lives saved	472	204	92	46
Major injuries prevented	522	225	101	52
minor injuries prevented	9,772	4,215	1,903	955

PDO crashes affected		28,471	12,305	5,549	2,775

CT					
Odds Ratio:	1.150		Person-based logit		
Speed Limiter Set at		60 mph	65 mph	68 mph	70 mph
Lives saved		466	201	91	46
Major injuries prevented		514	222	100	51
minor injuries prevented		9,642	4,164	1,888	952
PDO crashes affected		28,109	12,124	5,489	2,775

Single unit trucks

SUT					
Odds Ratio:	1.014		Vehicle-based logit		
Speed Limiter Set at		60 mph	65 mph	68 mph	70 mph
Lives saved		3	1	0	0
Major injuries prevented		3	1	0	0
minor injuries prevented		54	17	7	3
PDO crashes affected		181	60	19	8

SUT					
Odds Ratio:	1.035		Person-based logit		
Speed Limiter Set at		60 mph	65 mph	68 mph	70 mph
Lives saved		6	2	1	0
Major injuries prevented		7	2	1	0
minor injuries prevented		128	42	16	8
PDO crashes affected		372	121	47	21

SUT					
Odds Ratio:	1.079		Vehicle-based logit		
Speed Limiter Set at		60 mph	65 mph	68 mph	70 mph
Lives saved		12	4	2	1
Major injuries prevented		13	4	2	1
minor injuries prevented		240	81	32	15
PDO crashes affected		698	236	91	42

SUT				
Odds Ratio:	1.097	Person-based logit		
Speed Limiter Set at	60 mph	65 mph	68 mph	70 mph
Lives saved	14	5	2	1
Major injuries prevented	15	5	2	1
minor injuries prevented	282	97	38	18
PDO crashes affected	820	282	111	52

SUT				
Odds Ratio:	1.053	Vehicle-based logit		
Speed Limiter Set at	60 mph	65 mph	68 mph	70 mph
Lives saved	9	3	1	1
Major injuries prevented	10	3	1	1
minor injuries prevented	176	59	23	10
PDO crashes affected	515	171	65	30

SUT				
Odds Ratio:	1.068	Person-based logit		
Speed Limiter Set at	60 mph	65 mph	68 mph	70 mph
Lives saved	11	4	1	1
Major injuries prevented	12	4	2	1
minor injuries prevented	218	73	28	14
PDO crashes affected	637	214	84	39

Buses

BUS				
Odds Ratio:	1	Vehicle-based logit		
Speed Limiter Set at	60 mph	65 mph	68 mph	70 mph
Lives saved	0	0	0	0
Major injuries prevented	0	0	0	0
minor injuries prevented	0	0	0	0
PDO crashes affected	0	0	0	0

BUS		
Odds Ratio:	1.024	Person-based logit

Speed Limiter Set at		60 mph	65 mph	68 mph	70 mph
Lives saved		3	1	0	0
Major injuries prevented		3	1	0	0
minor injuries prevented		62	223	9	5
PDO crashes affected		180	67	27	13

BUS					
Odds Ratio:	1.081		Vehicle-based logit		
Speed Limiter Set at		60 mph	65 mph	68 mph	70 mph
Lives saved		6	3	1	0
Major injuries prevented		7	3	1	1
minor injuries prevented		129	61	20	10
PDO crashes affected		376	176	60	29

BUS					
Odds Ratio:	1.165		Person-based logit		
Speed Limiter Set at		60 mph	65 mph	68 mph	70 mph
Lives saved		12	5	2	1
Major injuries prevented		14	6	3	1
minor injuries prevented		252	106	46	23
PDO crashes affected		736	309	135	66

BUS					
Odds Ratio:	1.120		Vehicle-based logit		
Speed Limiter Set at		60 mph	65 mph	68 mph	70 mph
Lives saved		8	4	1	1
Major injuries prevented		9	4	2	1
minor injuries prevented		166	136	28	14
PDO crashes affected		486	235	81	39

BUS					
Odds Ratio:	1.098		Person-based logit		
Speed Limiter Set at		60 mph	65 mph	68 mph	70 mph
Lives saved		9	4	2	1
Major injuries prevented		10	4	2	1
minor injuries		188	75	32	16

prevented				
PDO crashes affected	546	218	93	45

Note that Appendix I shows the potential benefits of limiting the maximum allowable speed to 68 mph and 60 mph.

Appendix B Costs associated with retrofitting heavy vehicles with a speed limiting device

For the number of heavy trucks on the road, we applied the survivability rates to the heavy vehicles sold since 1992. It showed that a total of 2,096,145 Class 7 & 8 heavy vehicles would be on the road. Among the 2 million heavy vehicles, about 40% were manufactured in 2002 and later. These vehicles would be equipped with an electronic speed limiting device. With a $2,000 unit cost for retrofitting a

Survivability for combination trucks [131]

Age	Total Annual Miles Traveled	Survivability	Weighted Miles Traveled
1	240,737	1.0000	240,737
2	226,110	0.9930	224,535
3	212,378	0.9810	208,351
4	199,486	0.9642	192,351
5	187,381	0.9432	176,733
6	176,017	0.9181	161,599
7	165,346	0.8894	147,061
8	155,327	0.8575	133,198
9	145,919	0.8230	120,085
10	137,085	0.7860	107,748
11	128,789	0.7473	96,239
12	120,999	0.7071	85,559
13	113,683	0.6660	75,708
14	106,813	0.6244	66,689
15	100,360	0.5826	58,471
16	94,300	0.5411	51,028
17	88,609	0.5003	44,332
18	83,263	0.4604	38,338
19	78,242	0.4217	32,998
20	73,526	0.3845	28,273
21	69,096	0.3490	24,112
22	64,935	0.3152	20,470

[131] Preliminary Regulator Impact Analysis for FMVSS No. 136 Electronic Stability Control Systems

On Truck Tractors and Motorcoaches, August 2011.

23	61,026	0.2835	17,300
24	57,354	0.2537	14,552
25	53,905	0.2260	12,180
26	50,664	0.2004	10,155
27	47,620	0.1769	8,424
28	44,759	0.1554	6,957
29	42,072	0.1359	5,718
30	39,547	0.1183	4,677
31	37,175	0.1025	3,809
32	34,945	0.0884	3,090
33	32,851	0.0759	2,493
34	30,883	0.0649	2,004
35	29,033	0.0552	1,602
Total	3,530,235		2,427,576

Appendix C VSL

Monetized Benefits

Effective in February 2013 the Office of the Secretary for the U.S. DOT issued revised guidance regarding the treatment of value of a statistical life (VSL) in regulatory analyses. The new guidance establishes a VSL of $9.2 million for analyses based on 2013 dollars, $9.1 million for analyses based on 2012 dollars, $8.98 million for analyses based on 2011 dollars, and $8.86 million for analyses based on 2010 analyses.

In the interim, we have adjusted the current estimates to reflect the revised value of a statistical life for both crash avoidance and crashworthiness Federal Motor Vehicle Safety Standards.

Year	Adjusted VSL millions	Survival Probability	Exposure (VMT)	Aggregate Exposure	Exposure Proportion	Mid-Year Discount Factor (3%)
2020	$9.20	1.0000	240,737	240,737	0.099168	0.98533
2021	$9.20	0.993	226,110	224,527	0.092491	0.95663
2022	$9.20	0.981	212,378	208,343	0.085824	0.92877
2023	$9.20	0.9642	199,486	192,344	0.079233	0.90172
2024	$9.20	0.9432	187,381	176,738	0.072805	0.87545
2025	$9.20	0.9181	176,017	161,601	0.066569	0.84995
2026	$9.20	0.8894	165,346	147,059	0.060579	0.82520
2027	$9.20	0.8575	155,327	133,193	0.054867	0.80116
2028	$9.20	0.823	145,919	120,091	0.049470	0.77783
2029	$9.20	0.786	137,085	107,749	0.044386	0.75517
2030	$9.20	0.7473	128,789	96,244	0.039646	0.73318
2031	$9.20	0.7071	120,999	85,558	0.035244	0.71182
2032	$9.20	0.666	113,683	75,713	0.031189	0.69109
2033	$9.20	0.6244	106,813	66,694	0.027474	0.67096
2034	$9.20	0.5826	100,360	58,470	0.024086	0.65142
2035	$9.20	0.5411	94,300	51,026	0.021019	0.63245
2036	$9.20	0.5003	88,609	44,331	0.018262	0.61402
2037	$9.20	0.4604	83,263	38,334	0.015791	0.59614
2038	$9.20	0.4217	78,242	32,995	0.013592	0.57878
2039	$9.20	0.3845	73,526	28,271	0.011646	0.56192
2040	$9.20	0.349	69,096	24,115	0.009934	0.54555
2041	$9.20	0.3152	64,935	20,468	0.008431	0.52966
2042	$9.20	0.2835	61,026	17,301	0.007127	0.51424
2043	$9.20	0.2537	57,354	14,551	0.005994	0.49926
2044	$9.20	0.226	53,905	12,183	0.005019	0.48472
2045	$9.20	0.2004	50,664	10,153	0.004182	0.47060
2046	$9.20	0.1769	47,620	8,424	0.003470	0.45689
2047	$9.20	0.1554	44,759	6,956	0.002865	0.44358
2048	$9.20	0.1359	42,072	5,718	0.002355	0.43066

2049	$9.20	0.1183	39,547	4,678	0.001927	0.41812
2050	$9.20	0.1025	37,175	3,810	0.001569	0.40594
2051	$9.20	0.0884	34,945	3,089	0.001272	0.39412
2052	$9.20	0.0759	32,851	2,493	0.001027	0.38264
2053	$9.20	0.0649	30,883	2,004	0.000826	0.37149
2054	$9.20	0.0552	29,033	1,603	0.000660	0.36067

Economic Costs (2010 $)

	MAIS1	MAIS2	MAIS3	MAIS4	MAIS5	Fatal
Medical	$3,801	$24,481	$70,902	$196,911	$441,618	$11,317
EMS	$109	$221	$416	$838	$855	$902
Market Prod	$2,858	$39,637	$110,088	$174,728	$352,178	$933,262
Household Prod	$0	$0	$0	$0	$0	$0
Ins. Adm.	$3,935	$9,370	$24,348	$37,372	$79,967	$28,322
Workplace	$341	$2,644	$5,776	$6,361	$11,091	$11,783
Legal	$1,410	$6,739	$19,645	$35,307	$91,197	$106,488
Crashworthiness Subtotal	$12,454	$83,092	$231,175	$451,517	$976,906	$1,092,074
Travel Delay	$1,426	$1,450	$1,490	$1,511	$1,529	$5,720
Property Damage	$7,959	$8,510	$16,027	$16,328	$15,092	$11,212
Crash Avoidance Total	$21,839	$93,052	$248,692	$469,356	$993,527	$1,109,006

Thus, fatal equivalents are required to be discounted to present value at 3 and 7 percent per OMB Circular A-4 where 3 percent represents the "social rate of time preference," and 7 percent represents the average rate of return to capital. Safety benefits occur when there is a crash severe enough to potentially result in occupant death and injury, which could be at any time during the safety seat's lifetime.

Appendix D AEO 2015 Early Reference Case Forecast of Retail Diesel Price (includes federal, state, and local taxes)

Year	Survival Probability	Exposure (VMT)	Aggregate Exposure	Exposure Proportion	Projected Diesel Unit Cost	Weighted
2020	1.0000	240,737	240,737	0.099168	$3.17	$0.31
2021	0.993	226,110	224,527	0.092491	$3.23	$0.30
2022	0.981	212,378	208,343	0.085824	$3.31	$0.28
2023	0.9642	199,486	192,344	0.079233	$3.37	$0.27
2024	0.9432	187,381	176,738	0.072805	$3.43	$0.25
2025	0.9181	176,017	161,601	0.066569	$3.49	$0.23
2026	0.8894	165,346	147,059	0.060579	$3.56	$0.22
2027	0.8575	155,327	133,193	0.054867	$3.63	$0.20
2028	0.823	145,919	120,091	0.049470	$3.70	$0.18
2029	0.786	137,085	107,749	0.044386	$3.77	$0.17
2030	0.7473	128,789	96,244	0.039646	$3.84	$0.15
2031	0.7071	120,999	85,558	0.035244	$3.92	$0.14
2032	0.666	113,683	75,713	0.031189	$4.00	$0.12
2033	0.6244	106,813	66,694	0.027474	$4.09	$0.11
2034	0.5826	100,360	58,470	0.024086	$4.17	$0.10
2035	0.5411	94,300	51,026	0.021019	$4.26	$0.09
2036	0.5003	88,609	44,331	0.018262	$4.35	$0.08
2037	0.4604	83,263	38,334	0.015791	$4.45	$0.07
2038	0.4217	78,242	32,995	0.013592	$4.55	$0.06
2039	0.3845	73,526	28,271	0.011646	$4.65	$0.05
2040	0.349	69,096	24,115	0.009934	$4.75	$0.05
2041	0.3152	64,935	20,468	0.008431	$4.75	$0.04
2042	0.2835	61,026	17,301	0.007127	$4.75	$0.03
2043	0.2537	57,354	14,551	0.005994	$4.75	$0.03
2044	0.226	53,905	12,183	0.005019	$4.75	$0.02
2045	0.2004	50,664	10,153	0.004182	$4.75	$0.02
2046	0.1769	47,620	8,424	0.003470	$4.75	$0.02
2047	0.1554	44,759	6,956	0.002865	$4.75	$0.01
2048	0.1359	42,072	5,718	0.002355	$4.75	$0.01
2049	0.1183	39,547	4,678	0.001927	$4.75	$0.01
2050	0.1025	37,175	3,810	0.001569	$4.75	$0.01
2051	0.0884	34,945	3,089	0.001272	$4.75	$0.01
2052	0.0759	32,851	2,493	0.001027	$4.75	$0.00
2053	0.0649	30,883	2,004	0.000826	$4.75	$0.00
2054	0.0552	29,033	1,603	0.000660	$4.75	$0.00
						$3.66 in 2013
						$3.43 in 2010, w/ CPI

Appendix E GHG CO2 cost and Pollutant per gallon of fuel

CO2 cost discounted at 3%

Year	Cost of CO-2	Survival Probability	Exposure (VMT)	Aggregate Exposure	Exposure Proportion	Value
2017	$40.55	1.0000	240,737	240737	0.0992	$ 4.02
2018	$41.59	0.9930	226,110	224527	0.0925	$ 3.85
2019	$43.67	0.9810	212,378	208343	0.0858	$ 3.75
2020	$44.71	0.9642	199,486	192344	0.0792	$ 3.54
2021	$44.71	0.9432	187,381	176738	0.0728	$ 3.26
2022	$45.75	0.9181	176,017	161601	0.0666	$ 3.05
2023	$46.79	0.8894	165,346	147059	0.0606	$ 2.83
2024	$47.83	0.8575	155,327	133193	0.0549	$ 2.62
2025	$48.87	0.8230	145,919	120091	0.0495	$ 2.42
2026	$49.91	0.7860	137,085	107749	0.0444	$ 2.22
2027	$50.95	0.7473	128,789	96244	0.0396	$ 2.02
2028	$51.99	0.7071	120,999	85558	0.0352	$ 1.83
2029	$53.03	0.6660	113,683	75713	0.0312	$ 1.65
2030	$54.07	0.6244	106,813	66694	0.0275	$ 1.49
2031	$54.07	0.5826	100,360	58470	0.0241	$ 1.30
2032	$55.11	0.5411	94,300	51026	0.0210	$ 1.16
2033	$56.15	0.5003	88,609	44331	0.0183	$ 1.03
2034	$57.19	0.4604	83,263	38334	0.0158	$ 0.90
2035	$58.23	0.4217	78,242	32995	0.0136	$ 0.79
2036	$59.27	0.3845	73,526	28271	0.0116	$ 0.69
2037	$60.31	0.3490	69,096	24115	0.0099	$ 0.60
2038	$61.35	0.3152	64,935	20468	0.0084	$ 0.52
2039	$62.39	0.2835	61,026	17301	0.0071	$ 0.44
2040	$63.43	0.2537	57,354	14551	0.0060	$ 0.38
2041	$64.47	0.2260	53,905	12183	0.0050	$ 0.32
2042	$65.51	0.2004	50,664	10153	0.0042	$ 0.27
2043	$66.55	0.1769	47,620	8424	0.0035	$ 0.23
2044	$67.59	0.1554	44,759	6956	0.0029	$ 0.19
2045	$68.63	0.1359	42,072	5718	0.0024	$ 0.16
2046	$69.67	0.1183	39,547	4678	0.0019	$ 0.13
2047	$70.71	0.1025	37,175	3810	0.0016	$ 0.11
2048	$71.75	0.0884	34,945	3089	0.0013	$ 0.09
2049	$72.79	0.0759	32,851	2493	0.0010	$ 0.07
2050	$73.83	0.0649	30,883	2004	0.0008	$ 0.06
2051	$73.83	0.0552	29,033	1603	0.0007	$ 0.05
2052	$73.83	0.0000	0	0	0.0000	$ -
2053	$73.83	0.0000	0	0	0.0000	$ -
2054	$73.83	0.0000	0	0	0.0000	$ -
				2,427,564	1.0000	$48.06

The SCC values are based on the Interagency Working Group guidance, specifically Appendix A of the November 2013 revision. The values are already discounted at 3%, in 2010 dollars. Note that due to limited data, in order to increase accuracy, we use 2017 as the start year with 34 future years instead of using 2020 as the start year with 31 future years.

Pollutant per gallon of fuel

Pollutant	Short Tons	Short Tons Per Gallon	Metric Tons Per Gallon	Grams Per Gallon
CO2	437.2734	0.0111	0.010069751	10069.75061
CO	0.1065	2.70346E-06	2.45254E-06	2.45253528
VOC	0.019	4.82307E-07	4.37542E-07	0.437541505
NOx	0.2423	6.15068E-06	5.57981E-06	5.579805618
PM	0.0052	1.32E-07	1.19748E-07	0.119748201
SOx	N/A (The EPA quantifier tool does not output SOx data)			

Cost of pollutant

Pollutant	Cost per short ton	Cost per metric ton
CO2	--	$48.06
CO	$0	
VOC	$1,700	
NOx	$6,700	
PM	$306,500	
SOx	$39,600	

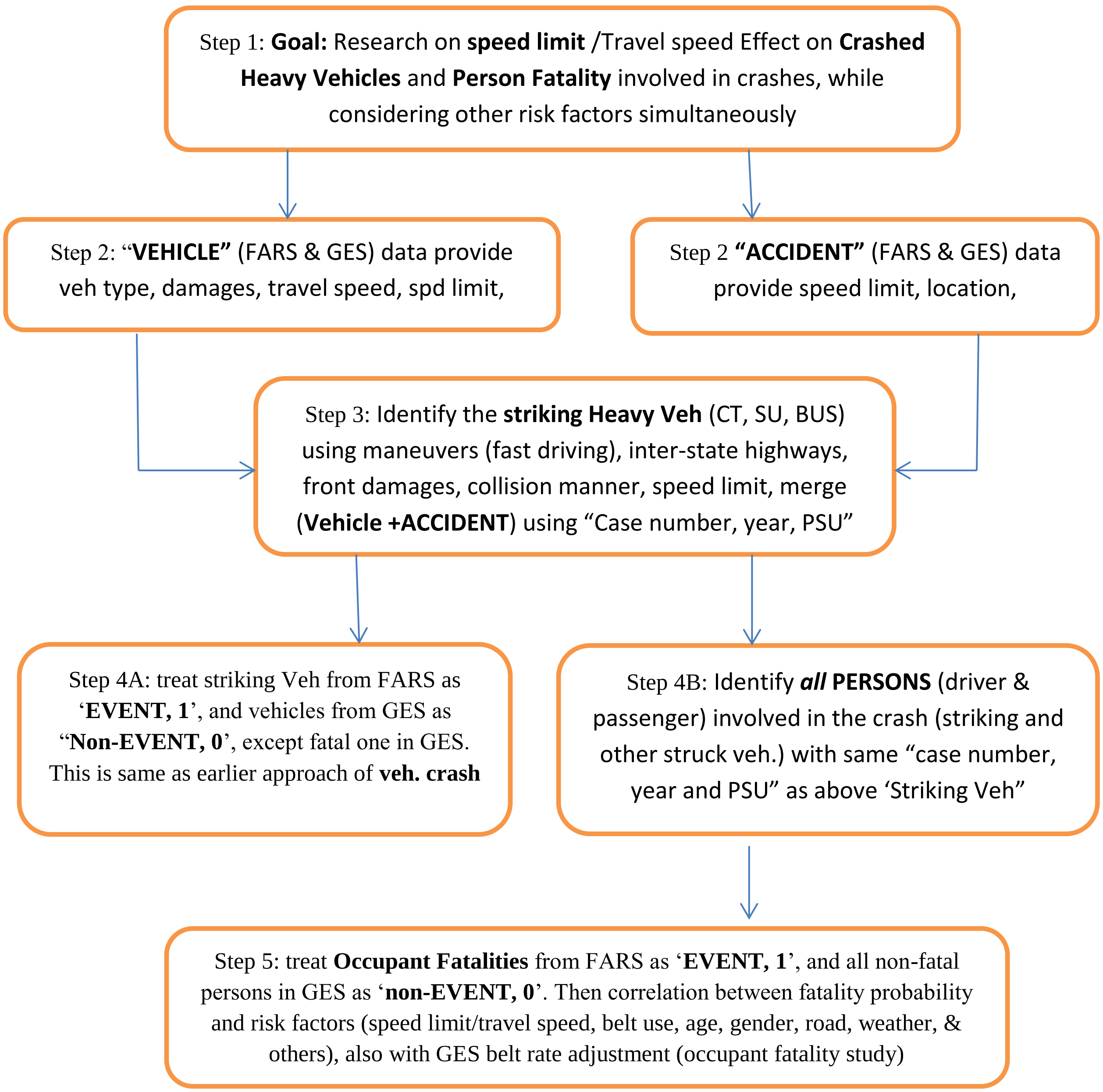
GHG savings with 65 mph speed limiting device

Gallons of Diesel Saved	Pollutant	Benefit (2010$, in Millions)	Quantity Reduced	Unit
343,985,257	CO2	$166.48	3,463,846	(metric tons)
	CO	$0.00	844	(short tons)
	VOC	$0.28	151	(short tons)
	NOx	$14.18	1,919	(short tons)
	PM	$13.92	41	(short tons)
	SOx	N/A	N/A	
	Total	$194.85	3,466,800	

The monetized CO2 values used the 3% case for the central analysis (as NHTSA did in the MD/HD Phase 1 rulemaking and the 2017-2025 light duty rulemaking).

Appendix F: SAS Programming Flowchart and Code

Data Flow-chart and SAS Code for Speed Limiter's Impact on Heavy Vehicle Crashes and Occupant Fatalities



Data Flowchart used for Vehicle based and Person-based Approaches

Appendix G Calculation used for the impacts on small business

CT

<table>
<tr><td colspan="3">Percent of the total travel distance by driven by owner-operator:</td><td colspan="5">30%</td></tr>
<tr><td colspan="3">Total travel distance by tractor trucks</td><td>81,778</td><td colspan="4">million miles</td></tr>
<tr><td colspan="3">Total travel distance by tractor truck owner-operators</td><td>24,533</td><td colspan="4">million miles</td></tr>
<tr><td colspan="3">Percent of the affected owner-operators, i.e., exceed Max. HOS</td><td>2%</td><td colspan="4"></td></tr>
<tr><td colspan="3">Total distance traveled by owner-operators, affected by the limiter</td><td>440</td><td colspan="4">million miles</td></tr>
<tr><td>On average CMV drivers are paid</td><td>$0.32</td><td>per mile, and</td><td colspan="2">it ranges from</td><td>$0.27</td><td>to</td><td>$0.42</td></tr>
<tr><td colspan="8">We assumed that owner-operator would make the upper range of labor income per hour. Therefore,</td></tr>
<tr><td colspan="3">The labor income of current owner-operators was estimated to be</td><td>$185</td><td colspan="4">million</td></tr>
<tr><td colspan="8">If we assume that 100% of the affected (owner-operators) are hired as independent contractors,</td></tr>
<tr><td colspan="3">For the affected</td><td>440</td><td colspan="4">million miles,</td></tr>
<tr><td colspan="3">the affected owner-operators would earn (in labor income)</td><td>$141</td><td colspan="4">million</td></tr>
<tr><td colspan="3">Therefore, owner-operators, overall, could potentially lose</td><td>$44</td><td colspan="4">million</td></tr>
</table>

SUT

<table>
<tr><td colspan="3">Percent of the total travel distance by driven by owner-operator:</td><td colspan="5">30%</td></tr>
<tr><td colspan="3">Total travel distance by SUTs</td><td>10,821</td><td colspan="4">million miles</td></tr>
<tr><td colspan="3">Total travel distance by SUT owner-operators, assumed</td><td>3,246</td><td colspan="4">million miles</td></tr>
<tr><td colspan="3">Percent of the affected owner-operators</td><td>2%</td><td colspan="4"></td></tr>
<tr><td colspan="3">Total distance traveled by owner-operators, affected by the limiter</td><td>58</td><td colspan="4">million miles</td></tr>
<tr><td>On average CMV drivers are paid</td><td>$0.32</td><td>per mile, and</td><td colspan="2">it ranges from</td><td>$0.27</td><td>to</td><td>$0.42</td></tr>
<tr><td colspan="8">We assumed that owner-operator would make the upper range of labor income per hour. Therefore,</td></tr>
<tr><td colspan="3">The labor income of current owner-operators was estimated to be</td><td>$24</td><td colspan="4">million</td></tr>
<tr><td colspan="8">If we assume that 100% of the affected (owner-operators) are hired as independent contractors,</td></tr>
<tr><td colspan="3">For the affected</td><td>58</td><td colspan="4">million miles</td></tr>
<tr><td colspan="3">the affected owner-operators would earn (in labor income)</td><td>$19</td><td colspan="4">million</td></tr>
<tr><td colspan="3">Therefore, owner-operators, overall, could potentially lose</td><td>$6</td><td colspan="4">million</td></tr>
</table>

Bus

Percent of the total travel distance by driven by owner-operator:			100%			
Total travel distance by **tractor trucks**			**2,624**	million miles		
Total travel distance by **tractor truck owner-operators**			2,624	million miles		
Percent of the affected owner-operators			2%			
Total distance traveled by owner-operators, affected by the limiter			47	million miles		
On average CMV drivers are paid	$0.32	per mile, and	it ranges from	$0.27	to	$0.42
We assumed that owner-operator would make the upper range of labor income per hour. Therefore,						
The labor income of current owner-operators was estimated to be			$20	million		
If we assume that 100% of the affected (owner-operators) are hired as independent contractors,						
For the affected			47	million miles		
the affected owner-operators would earn (in labor income)			$15	million		
Therefore, owner-operators, overall, could potentially lose			$5	million		

Appendix H SAS codes used for the analysis

/* ******* Introduction to SAS Coding :

********** Four Main Parts of SAS Coding *************************

1. *GES Data (ACCident, VEHicle, and PERson), and 'Ganalysis' (for vehicle crash), 'Striking_CT_G' (for striking vehicle crash), and 'Ganalysis_Per' ('Belt_RD75' is a similar with lower GES belt rate, for fatality analysis) are three key files (pages 1-9, steps 1-3);*
2. *FARS data (ACCident, VEHicle, and PERson), and 'Fanalysis', 'Striking_CT_F' (for striking vehicle crash), and 'Fanalysis_PER' (for fatality analysis) are three key files for vehicle crash or occupant fatalities, respectively (page 9-15, steps 4-6).*
3. *Combination use of GES and FARS where FARS data are treated as crash event (nominator) and GES as non-event (denominator) , and 'Analysis' data is used for striking vehicle crash analysis, and 'Analysis_PER' (or 'Analysis_PER75', belt reduction in GES) are used for occupant injury research (pages 15-19, steps 7-8).*
4. *Results to match summary report of Chapters 2, 3, 4 (pages 20-26, steps 9-10) – summary of target population (Ch2), Vehicle Crash (CH3), and Fatality analysis (CH4).*
5. *Several speed profiles are considered – speed limits from GES/FARS, travel speed profile suggested by Mack-Blackwell (Normal distributions and five mean values), Travel speed from recent field test observations (Normal distributions or five mean values), and travel speeds from FARS/GES databases.*
6. *In multiple model, factors into considerations including – several speed profiles, road surf condition, lane number, weather, occupant age, gender, seating position, belt use status.*
7. *The SAS code also referred to Eun-Ha Choi's and Vehicle Type Definitions in recent FARS/GES Manuals, and also referred to Robert Sivinski' earlier mixed use of GES and FARS database for modeling (e.g., treating FARS as fatal crash events, with weight being 1.0 and unknown PSU assigned to FARS data). Modeling using one database alone, GES or FARS, was also performed.*

   Updated, March 2016

   ****

*/

```
/* step 1 Location of Data  */

libname limiter 'C:\Users\jingshu.wu\Desktop\FMVSS140\run_bob';
run;

/* March 2016 updating*/
LIBNAME DIR "C:\Users\jingshu.wu\Desktop\FMVSS140\run_bob\";

OPTIONS NOFMTERR NODATE NONUMBER;

/* step 2 year ranges 2004-2013  and format uses  Aug 2014 */
%LET YR1=2004;
%LET YR2=2006;
%LET YR3=2013;                    /* NEW 10 years data!!!  */
/* change  10 years data*/
%LET YR4=2013-2004;

/* step 1 format and data source  */

 /*  ************GES data   ************* */
```

```
/* GES LIBRARIES */
libname ges88 'r:\files\ges88\';
libname ges89 'r:\files\ges89\';
libname ges90 'r:\files\ges90\';
libname ges91 'r:\files\ges91\';
libname ges92 'r:\files\ges92\';
libname ges93 'r:\files\ges93\';
libname ges94 'r:\files\ges94\';
libname ges95 'r:\files\ges95\';
libname ges96 'r:\files\ges96\';
libname ges97 'r:\files\ges97\';
libname ges1998 'r:\files\ges98\';
libname ges1999 'r:\files\ges99\';
libname ges2000 'r:\files\ges00\';
libname ges2001 'r:\files\ges01\';
libname ges2002 'r:\files\ges02\';
libname ges2003 'r:\files\ges03\';
libname ges2004 'r:\files\ges04\';
libname ges2005 'r:\files\ges05\';
libname ges2006 'r:\files\ges06\';
libname ges2007 'r:\files\ges07\';
libname ges2008 'r:\files\ges08\';
libname ges2009 'r:\files\ges09\';
libname ges2010 'r:\files\ges10\';
libname ges2011 'r:\files\ges11\';
libname ges2012 'r:\files\ges12\';
libname ges2013 'r:\files\ges13\';

/*  format  */
options nofmterr;

 /* vehicle and format  sources  */
      proc format;
            value spltypefmt 1="55 mph "
                             2="60 mph"
                             3="65 mph"
                             4="70 mph"
                              5="75 mph"
                              6="80 mph"
                              7="others";
            value speedfmt 1="Speeding"
                           2="Non-Speeding";
      run;

/*  step 1  GES data: accident, Vehicle and Person */
data Accident_G (keep=year casenum psu psustrat stratum weight ratwgt int_hwy
sur_cond
maxsev max_SEV NOINJ spd_lim sp_limit spedLIM_h splTYPE post_V post_V2
drive_V weather weather_c
num_lan Vnum_lan no_lanes lane_c VE_FORMS VEH_INVL);
set
         ges1998.accident(in=yr1998)
         ges1999.accident(in=yr1999)
         ges2000.accident(in=yr2000)
         ges2001.accident(in=yr2001)
         ges2002.accident(in=yr2002)
         ges2003.accident(in=yr2003)
```

```
          ges2004.accident(in=yr2004)
          ges2005.accident(in=yr2005)
          ges2006.accident(in=yr2006)
          ges2007.accident(in=yr2007)
          ges2008.accident(in=yr2008)
          ges2009.accident(in=yr2009)
          ges2010.accident(in=yr2010)
          ges2011.accident(in=yr2011)
          ges2012.accident(in=yr2012)
          ges2013.accident(in=yr2013);

              format year best12.;
        /** 1988-2009 GES YEAR variable was length 4. after 2009 length = 8
**/
              length year 8.;

           if yr1998 then year=1998;
          else if yr1999 then year=1999;
          else if yr2000 then year=2000;
          else if yr2001 then year=2001;
          else if yr2002 then year=2002;
          else if yr2003 then year=2003;
          else if yr2004 then year=2004;
          else if yr2005 then year=2005;
          else if yr2006 then year=2006;
          else if yr2007 then year=2007;
          else if yr2008 then year=2008;
          else if yr2009 then year=2009;
          else if yr2010 then year=2010;
          else if yr2011 then year=2011;
          else if yr2012 then year=2012;
           else if yr2013 then year=2013;

       /* update NOV 2015  */

/* interstate  onlY  !!    *************  */
            if int_hwy=1;             /* limited NOV 2015  */

* excluding fatal crashes in GES;
             *if maxsev = 4 then weight=0;
            /* do this later with ANALYSIS data, use FARS as fatal instead
*/
run;

/* update referring to En-Ha and Liu's VEHICE    DEC 2015  */
data Vehicle_G (keep=year casenum vehno veh_no psu stratum psustrat weight
ratwgt gvwr
p_crash1 p_crash2 VSPD_LIM  speed body speed trav_sp drive_V post_V post_V2
body body_C BDYTYP_IM bdytyp_h impact impact1 impact2 impact1_IM man_col
tow_veh trailer ve_FORMS ve_inVL);
     set
       ges1998.vehicle(in=yr1998 rename=(vehno=veh_no))
       ges1999.vehicle(in=yr1999 rename=(vehno=veh_no))
       ges2000.vehicle(in=yr2000 rename=(vehno=veh_no))
       ges2001.vehicle(in=yr2001 rename=(vehno=veh_no))
       ges2002.vehicle(in=yr2002 rename=(vehno=veh_no))
       ges2003.vehicle(in=yr2003 rename=(vehno=veh_no))
```

```
        ges2004.vehicle(in=yr2004 rename=(vehno=veh_no))
        ges2005.vehicle(in=yr2005 rename=(vehno=veh_no))
        ges2006.vehicle(in=yr2006 rename=(vehno=veh_no))
        ges2007.vehicle(in=yr2007 rename=(vehno=veh_no))
        ges2008.vehicle(in=yr2008 rename=(vehno=veh_no))
        ges2009.vehicle(in=yr2009 rename=(vehno=veh_no))
        ges2010.vehicle(in=yr2010 rename=(vehno=veh_no))
       ges2011.vehicle(in=yr2011)
       ges2012.vehicle(in=yr2012)
       ges2013.vehicle(in=yr2013);

          if yr1998 then year=1998;
         else if yr1999 then year=1999;
         else if yr2000 then year=2000;
         else if yr2001 then year=2001;
         else if yr2002 then year=2002;
         else if yr2003 then year=2003;
         else if yr2004 then year=2004;
         else if yr2005 then year=2005;
         else if yr2006 then year=2006;
         else if yr2007 then year=2007;
         else if yr2008 then year=2008;
         else if yr2009 then year=2009;
         else if yr2010 then year=2010;
         else if yr2011 then year=2011;
         else if yr2012 then year=2012;
         else if yr2013 then year=2013;

/*  best 12 numerical format to date format  */
*** CT/ST ***;
if  year<= 1998 then do;
   if (bdytyp_h in (60 64 78) and (1<=trailer<=4)) or bdytyp_h=66       then
body_c =1;
      else if  bdytyp_h in (60 64 78) and trailer in (0 9) then   body_C =2;
 end;

else if 1999<=year<=2008 then do;
   if (bdytyp_h in (60 64 78) and (2<=trailer<=5)) or bdytyp_h=66       then
body_C =1;
      else if  bdytyp_h in (60 64 78) and trailer in (1 6) then   body_C =2;
 end;

else if year=2009 then do;
   if (BDYTYP_H IN (60,64,78) AND 1<=TOW_VEH<=4) OR BDYTYP_H=66   then
body_C=1;
      else if  BDYTYP_H IN (60,64,78) AND TOW_VEH IN (0,5,6,9)    then
body_C=2;
 end;

else if year>=2010 then do;
   if (BDYTYP_IM IN (60,61,62,63,67,68,71,72,78) AND 1<=TOW_VEH<=4) OR
BDYTYP_IM=66 then body_C=1;
   else if  BDYTYP_IM IN (60,61,62,63,67,68,71,72,78) AND TOW_VEH IN
(0,5,6,9) then body_C=2;
 end;

*** BUS ***;
```

```
  if year<=2009 then do;
   IF 50<=BDYTYP_H<=59 THEN BODY_C =3;
  end;

  else if year>=2010 then do;
   IF 50<=BDYTYP_IM<=59 THEN BODY_C=3;
  end;
*** PV ***;
 if year<=2009 then do;
   IF (1<=bdytyp_h<=11) or (bdytyp_h=17) or
    (bdytyp_h in (24,25,45,47,48)) or (14<=bdytyp_h<=22) or
(28<=bdytyp_h<=41)
   then body_C =4;
 end;

 else if year>=2010 then do;
   IF (1<=BDYTYP_IM<=11) or (BDYTYP_IM=17) or
    (BDYTYP_IM in (24,25,45,47,48)) or (14<=BDYTYP_IM<=22) or
(28<=BDYTYP_IM<=41)
   then body_c =4;
 end;
/* following travel speed from database  */
drive_V =.;
if (year<=2008 and 0<speed<=30) OR (year>=2009 and 0< TRAV_SP<=30) then
drive_V= 1;  *'000-30';
else if (year<=2008 and 31<=speed<=40) OR ( year>=2009 and 31<= TRAV_SP <=40)
then drive_V= 2;   *'31-40';
else if (year<=2008 and 41<=speed<=50) OR (year>=2009 and 41<= TRAV_SP <=50)
then drive_V= 3;   *'41-50';
else if (year<=2008 and 51<=speed<=55) OR (year >=2009 and 51<= TRAV_SP <=55)
then drive_V= 4;   *'51-55';
else if (year<=2008 and 56<=speed<=60) OR (year >=2009 and 56<= TRAV_SP <=60)
then drive_V= 5;    *'56-60';
else if (year<=2008 and 61<=speed<=65) OR (year >=2009 and 61<= TRAV_SP <=65)
then drive_V= 6;    *'61-65';
else if (year<=2008 and 66<=speed<=70) OR (year >=2009 and 66<= TRAV_SP <=70)
then drive_V= 7;    *'66-70';
else if (year<=2008 and 71<=speed<=75) OR (year >=2009 and 71<= TRAV_SP <=75)
then drive_V= 8;       *''71-75';
else if (year<=2008 and 76<=speed<=80) OR
(year >=2009 and 76<= TRAV_SP <=149 and TRAV_SP not in (98,99,998,999))then
drive_V= 9;

*if p_crash1 in (0,4,5,7,8,9,12,13,3,10,11) then delete;
          /*  later in merged data maneuvers keep 3, 10, 11, turning done NOV
2015 */
if body_C in (1,2,3,4);
run;

/* add PERSON file NOV 30  */
data person_G (keep=year casenum vehno veh_no psu stratum psustrat weight
ratwgt rest_sys rest_use
age sex sex_c inj_SEV seat_pos seat_c per_typ per_type max_SEV);
     set
       ges1998.person(in=yr1998 rename=(vehno=veh_no))
       ges1999.person(in=yr1999 rename=(vehno=veh_no))
       ges2000.person(in=yr2000 rename=(vehno=veh_no))
```

```
        ges2001.person(in=yr2001 rename=(vehno=veh_no))
        ges2002.person(in=yr2002 rename=(vehno=veh_no))
        ges2003.person(in=yr2003 rename=(vehno=veh_no))
        ges2004.person(in=yr2004 rename=(vehno=veh_no))
        ges2005.person(in=yr2005 rename=(vehno=veh_no))
        ges2006.person(in=yr2006 rename=(vehno=veh_no))
        ges2007.person(in=yr2007 rename=(vehno=veh_no))
        ges2008.person(in=yr2008 rename=(vehno=veh_no))
        ges2009.person(in=yr2009 rename=(vehno=veh_no))
        ges2010.person(in=yr2010 rename=(vehno=veh_no))
        ges2011.person(in=yr2011)
      ges2012.person(in=yr2012)
      ges2013.person(in=yr2013);

       if yr1998 then year=1998;
          else if yr1999 then year=1999;
          else if yr2000 then year=2000;
          else if yr2001 then year=2001;
          else if yr2002 then year=2002;
          else if yr2003 then year=2003;
          else if yr2004 then year=2004;
          else if yr2005 then year=2005;
          else if yr2006 then year=2006;
          else if yr2007 then year=2007;
          else if yr2008 then year=2008;
          else if yr2009 then year=2009;
          else if yr2010 then year=2010;
          else if yr2011 then year=2011;
          else if yr2012 then year=2012;
          else if yr2013 then year=2013;

       if 11<=seat_pos <=19 then seat_c =1;
       else if 20<=seat_pos <=54 then seat_c =0;
       else seat_c =.;

       if sex =2 then sex_c =1;  /*female  */
       else sex_c =0;

if per_TYP in (1,2,9) OR per_TYPE in (1,2,9);
/* occupants only */
run;

proc sort data=person_G;
by year psu casenum veh_no;
run;
proc sort data=accident_G;
by year psu casenum;
proc sort data=vehicle_G;
by year psu casenum veh_no;run;

/* step 2 merge data   *****************  */

data ganalysis; *(drop=int_hwy);
merge vehicle_G(in=veh) accident_G(in=acc);         /* two vehicle files to
combine  DEC 2015)  */
by year psu casenum;
if acc and VEH;
```

```
  ratwgt=weight;        /* to agree with FARS later  */

if year le 2008 then do;
        if 20<=SPD_LIM <=30 OR 20<=spedLIM_h <=30 then spltype=1;
            else if 31<=SPD_LIM<=40 OR 31<=spedLIM_h <=40 then spltype=2;
            else if 41<=SPD_LIM<=50 OR 41 <=spedLIM_h<=50 then spltype=3;
        else if SPD_LIM=55 OR spedLIM_h =55 then spltype=4;
            else if SPD_LIM=60 OR spedLIM_h =60 then spltype=5;
            else if SPD_LIM=65 OR spedLIM_h =65 then spltype=6;
        else if SPD_LIM=70 OR spedLIM_h =70 then spltype=7;
            else if SPD_LIM=75 OR spedLIM_h =75 then spltype=8;
            else if SPD_LIM=80 OR spedLIM_h =80 then spltype=9;
            else spltype= .;                /* missing  */
      end;

else if year ge 2009 then do;                    /* sp_limit for 2009 only
*/
        if 20<= VSPD_LIM <=30 OR 20<= sp_limit <=30 then spltype=1;
            else if 31 <=VSPD_LIM <=40 or 31 <=sp_limit <=40 then spltype=2;
            else if 41 <=VSPD_LIM <=50 or 41 <=sp_limit <=50then spltype=3;
        else if VSPD_LIM=55 OR sp_limit =55  then spltype=4;
            else if VSPD_LIM=60 OR sp_limit =60 then spltype=5;
            else if VSPD_LIM=65 OR sp_limit = 65 then spltype=6;
            else if VSPD_LIM=70 OR sp_limit =70 then spltype=7;
            else if VSPD_LIM=75 OR sp_limit = 75 then spltype=8;
            else if VSPD_LIM=80 OR sp_limit =80 then spltype=9;
            else spltype= .;                   /* missing  */
      end;

      if weather in (2,3,4,5,6,7,8,10,11,12) then weather_c=1;
            else if weather in (0,1) then weather_c=0;
    if sur_cond in (2,3,4,5) then road_c=1;
            else if sur_cond =1 then road_c =0;
      if (num_Lan in (3,4,5,6,7) or Vnum_lan in (3,4,5,6) OR No_Lanes in
(3,4,5,6,7)) then lane_c=1;
      else if (num_Lan in (1,2) OR Vnum_lan in (1,2) OR No_Lanes in (1,2))
then lane_c=0;

run;

/*  data merge data  GES 1998 to 2013  */
proc sort data=Ganalysis;
by year psu casenum veh_no;
run;

/*  !!!! step 3 KEY striking Veh  data for all chapters  *******  */
/* choose body_C for CT, SU, and BUS here  */

      %LET striking_C = 1;        /* 1,2,3, or 4 */
data striking_CT_G;
set ganalysis;
/* if 10000 <= dam_area <20000;  /* old definition front crashes  */
if p_crash1 in (0,4,5,7,8,9,12,13) then delete;
   /* maneuvers keep 3, 10, 11, turning done NOV 2015 */
if impact1 in (1,11,12) or impact1_IM in (1,11,12) or IMPACT in (1,11,12)
OR PIMPACT in (1,11,12) Or PIMPACT1 in (1,11,12);
```

```
      *if (1<=VE_FORMS<=3 and year>=2011) OR (1<=VEH_INVL<=3 and 1988<= year
<=2010);
if 1<= splTYPE <=9 and int_hwy=1;
if body_C = &striking_C and (2000<=year <=2013); /* choose body_C for CT, SU,
and BUS here  */
run;

/* occupants associated with the crash by striking veh  **************  */
data ganalysis_per; *(drop=int_hwy);   /* from striking Veh and Body_C  */
merge striking_CT_G (in=a) person_G(in=b);
by year psu casenum;
if a and b;
      if inj_sev in (4,6) then fatal_c=1;
      else fatal_C=0;

if rest_sys in (0,7,30) OR rest_use in (0,7,30)then belt_c=1;  /* risky and
not used */
else if rest_sys in (1,2,3,4,5,6,8,10,11,12,21,22,23,28)
OR rest_use in (1,2,3,4,5,6,8,10,11,12,21,22,23,28) then belt_c=0;  /* used
belt */
else belt_c=. ;   /* missing unknown */

if spltype=4 then speed2=rannor(123) * 4 + 64.2;              /* mean and
standard error  */
else if spltype=5 then speed2=rannor(1234) * 4 + 65.5;
else if spltype=6 then speed2=rannor(12345) * 3.69 + 66.7;
else if spltype=7 then speed2=rannor(123456) * 4.55 + 68.6;
else if spltype=8 then speed2=rannor(1234567) * 5.63 + 72.3;
/*  means ONLY  ****************  */
if spltype =4 then speed3=64.2;
else if spltype=5 then speed3=65.5;            /* mean value only  */
else if spltype=6 then speed3=66.7;
else if spltype=7 then speed3=68.6;
else if spltype=8 then speed3=72.3;

if spltype=4 then speed4=rannor(123) * 3.52 + 62.07;              /* mean and
standard error  */
else if spltype=5 then speed4=rannor(1234) * 3.05 + 63.46;
else if spltype=6 then speed4=rannor(12345) * 3.77 + 66.63;
else if spltype=7 then speed4=rannor(123456) * 4.00 + 68.90;
else if spltype=8 then speed4=rannor(1234567) * 4.48 + 68.34;

if spltype=4 then speed4m = 62.07;             /* Markus mean and standard
error  */
else if spltype=5 then speed4m = 63.46;
else if spltype=6 then speed4m = 66.63;
else if spltype=7 then speed4m = 68.90;
else if spltype=8 then speed4m = 68.34;
run;


/* add GES person data, can use GES data alone for analysis  */
data limiter.GES_ACC_VEH_98_12; set Ganalysis; run;          /* save GES data
*/
data limiter.GES_ACC_VEH_PER98_12; set Ganalysis_per; run;

/*  *************   step 4 Bring in FARS cases */
```

```
libname fars98 'L:\farssas\fars98';
libname fars99 'L:\farssas\fars99';
libname fars00 'L:\farssas\fars00';
libname fars01 'L:\farssas\fars01';
libname fars02 'L:\farssas\fars02';
libname fars03 'L:\farssas\fars03';
libname fars04 'L:\farssas\fars04';
libname fars05 'L:\farssas\fars05';
libname fars06 'L:\farssas\fars06';
libname fars07 'L:\farssas\fars07';
libname fars08 'L:\farssas\fars08';
libname fars09 'L:\farssas\fars09';
libname fars10 'L:\farssas\fars10';
libname fars11 'L:\farssas\fars11';
libname fars12 'L:\farssas\fars12';
libname fars13 'L:\farssas\fars13';
libname library 'L:\farssas\formats\winfmt91.610';

options nofmterr;
options ls=150 pagesize=63 nofmterr formchar='|-„…†‡+‰Š‹OE+=|-/\<>*';

data Faccident1  (keep=year state st_case fatals sp_limit weather
Vlan_NUM lan_num no_lanes splTYPE sp_limit vspd_lim
sur_cond man_coll road_fnc harm_EV);
drop latitude longitud;
set
         fars98.accident(in=yr1998)
         fars99.accident(in=yr1999)
         fars00.accident(in=yr2000);

         if yr1998 then year=1998;
         else if yr1999 then year=1999;
         else if yr2000 then year=2000;
* interstate;
             if road_fnc in (1,2,11,12,13);             /* highway limited 5
types */
run;

data Faccident2  (keep=year state st_case fatals sp_limit weather
Vlan_NUM lan_num no_lanes splTYPE sp_limit vspd_lim
sur_cond man_coll road_fnc harm_EV);
drop latitude longitude;
set
          fars01.accident(in=yr2001)
         fars02.accident(in=yr2002)
         fars03.accident(in=yr2003)
         fars04.accident(in=yr2004)
         fars05.accident(in=yr2005)
         fars06.accident(in=yr2006)
         fars07.accident(in=yr2007)
         fars08.accident(in=yr2008)
         fars09.accident(in=yr2009)
         fars10.accident(in=yr2010)
         fars11.accident(in=yr2011)
         fars12.accident(in=yr2012)
         fars13.accident(in=yr2013);
```

```
            if yr2001 then year=2001;
         else if yr2002 then year=2002;
         else if yr2003 then year=2003;
         else if yr2004 then year=2004;
         else if yr2005 then year=2005;
         else if yr2006 then year=2006;
         else if yr2007 then year=2007;
         else if yr2008 then year=2008;
         else if yr2009 then year=2009;
         else if yr2010 then year=2010;
         else if yr2011 then year=2011;
         else if yr2012 then year=2012;
         else if yr2013 then year=2013;
* interstate;
             if road_fnc in (1,2,11,12,13);              /* NOV 2015 update
*/
run;

/*  1998 - 2012 = 15 years data  */
data Accident_F (keep=year state st_case fatals sp_limit weather
Vlan_NUM lan_num no_lanes splTYPE sp_limit vspd_lim
sur_cond man_coll road_fnc harm_EV);
set faccident1 faccident2;
 if road_fnc in (1,2,11,12,13);              /* feb 2016 update  */
run;

/* "speed limit" and "speeding" info. are in Vehicle file after 2010;   */
data vehicle_F (keep=year state st_case veh_no body_c body_typ gvwr WGTCD_TR
PWGTCD_TR
vin_WGT WT_C vspd_lim impact1 impact2 p_crash1 veh_man
trav_sp drive_V J_Knife M_HARM SEQ1 RollOVER);
set fars98.vehicle(in=cy98) fars99.vehicle(in=cy99) fars00.vehicle(in=cy00)
      fars01.vehicle(in=cy01)
      fars02.vehicle(in=cy02) fars03.vehicle(in=cy03) fars04.vehicle(in=cy04)
      fars05.vehicle(in=cy05) fars06.vehicle(in=cy06) fars07.vehicle(in=cy07)
      fars08.vehicle(in=cy08) fars09.vehicle(in=cy09) fars10.vehicle(in=cy10)
      fars11.vehicle(in=cy11) fars12.vehicle(in=cy12)
fars13.vehicle(in=cy13);

if cy98 then year=1998;
else if cy99 then year=1999; else if cy00 then year=2000; else if cy01 then
year=2001;
else if cy02 then year=2002; else if cy03 then year=2003; else if cy04 then
year=2004;
else if cy05 then year=2005; else if cy06 then year=2006; else if cy07 then
year=2007;
else if cy08 then year=2008; else if cy09 then year=2009; else if cy10 then
year=2010;
else if cy11 then year=2011; else if cy12 then year=2012; else if cy13 then
year=2013;

 *****;
/* refer to old program from Eun-Ha and Liu  */
* Vehicle type of FARS;                       /* update NOV 2015  */
/* CT define */
if ( body_typ in (60 61 62 63 64 67 71 72 78 79) and (1 le tow_veh le 4) )
   or body_typ=66 then body_C =1;
```

```
*** ST ***;
if body_typ in (60 61 62 63 64 67 71 72 78 79) and tow_veh in (0 5 9)
   then body_C =2;

***** BUS ***;
if 50 le body_typ le 59 then body_c =3;                /* update NOV 2015  */

*** PV ***;
if  (01 le body_typ le 11) or (14 le body_typ le 22) or (28 le body_typ le
41)
   or (45 le body_typ le 49)
   or (body_typ=79 and (tow_veh=0 or tow_veh=9))
   or (24 le body_typ le 25)
   then body_C =4;

if body_c in (1,2,3,4);                         /* update NOV 2015  */

drive_V =.;
if (0< TRAV_SP<=30) OR (0< SPeed <=30) then drive_V= 1;  *'000-30';
else if (31<= TRAV_SP <=40) OR (31<= SPeed <=40)then drive_V= 2;   *'31-40';
else if (41<= TRAV_SP <=50) OR (41<= SPeed <=50)then drive_V= 3;   *'41-50';
else if (51<= TRAV_SP <=55) OR (51<= SPeed <=55)then drive_V= 4;   *'51-55';
else if (56<= TRAV_SP <=60) OR (56<= SPeed <=60)then drive_V= 5;    *'56-60';
else if (61<= TRAV_SP <=65) OR (61<= SPeed <=65)then drive_V= 6;    *'61-65';
else if (66<= TRAV_SP <=70) OR (66<= SPeed <=70)then drive_V= 7;    *'66-70';
else if (71<= TRAV_SP <=75) OR (71<= SPeed <=75)then drive_V= 8;       *''71-
75';
else if (76<= TRAV_SP <=149 and TRAV_SP not in (98,99,998,999))
OR (76<= speed <=149 and speed not in (98,99,998,999)) then drive_V= 9;
*over 76 100-149';

WT_c=.;
if GVWR=1 or 1<=VIN_WGT <=9998 or WGTCD_TR in (1,2) or PWGTCD_TR in (1,2)
then WT_c=1;   /* passenger car  */
else if GVWR=2 or WGTCD_TR in (3,4,5,6) or PWGTCD_TR in (3,4,5,6) then
WT_c=2;        /* middle WT  */
else if GVWR=3 or WGTCD_TR in (7,8) or PWGTCD_TR in (7,8) then WT_c=3;   /*
heavy truck  */
run;

* "speed limit" and "speeding" info. are in Vehicle file after 2010;

proc sort data=accident_F;
by year  state st_case; run;
proc sort data=vehicle_F;
by year  state st_case veh_no; run;
proc sort data=person_f;
by year  state st_case veh_no; run;

/* step 5 merge data  *******  */

data fanalysis;
merge vehicle_F(in=veh) accident_F(in=acc);           /* try 2 typew of
vehicle files  */
by year  state st_case;
if veh and acc;
```

```
if year le 2009 then do;
        if 20<=SP_LIMIT <=30 then spltype=1;
            else if 31 <=SP_LIMIT <=40 then spltype=2;
            else if 41 <=SP_LIMIT <=50 then spltype=3;
            else if SP_LIMIT=55 then spltype=4;
            else if SP_LIMIT=60 then spltype=5;
            else if SP_LIMIT=65 then spltype=6;
        else if SP_LIMIT=70 then spltype=7;
            else if SP_LIMIT=75 then spltype=8;
        else if SP_LIMIT=80 then spltype=9;
            else splTYPE= .;    /* missing  */
      end;

else if year ge 2010 then do;
        if 20<= VSPD_LIM <=30 then spltype=1;
            else if 31 <=VSPD_LIM <=40 then spltype=2;
            else if 41 <=VSPD_LIM <=50 then spltype=3;
        else if VSPD_LIM=55 then spltype=4;
            else if VSPD_LIM=60 then spltype=5;
            else if VSPD_LIM=65 then spltype=6;
        else if VSPD_LIM=70 then spltype=7;
            else if VSPD_LIM=75 then spltype=8;
            else if VSPD_LIM=80 then spltype=9;
            else spltype= .;
      end;

      IF sur_COND IN (2,3,4,5,6,7) THEN ROAD_C =1;
      ELSE IF SUR_COND =1 THEN ROAD_C=0; /* DRY VS. WORSE  */
            if weather in (2,3,4,5,6,7) then weather_c=1;
            else if weather in (0,1)then weather_c=0;
      if No_Lanes in (3,4,5,6,7) or VNUM_lan in (3,4,5,6,7) then lane_c=1;
      else if No_Lanes in (1,2) or VNUM_lan in (1,2) then lane_c=0;
/* update NOV 2015  */

psu=999;    /* unknown data from FARS earlier Bob’s approach comments  */
psustrat=999;
ratwgt=1;          /* use each fatal crash as 1 in overall FARS and GES data
*/
run;

proc sort data=Fanalysis;
by year  state st_case veh_no; run;

data person_F (keep=year state st_case veh_no age sex sex_c rest_use seat_pos
seat_c inj_SEV per_TYP per_TYPE);
set fars98.person(in=cy98) fars99.person(in=cy99) fars00.person(in=cy00)
      fars01.person(in=cy01)
      fars02.person(in=cy02) fars03.person(in=cy03) fars04.person(in=cy04)
      fars05.person(in=cy05) fars06.person(in=cy06) fars07.person(in=cy07)
      fars08.person(in=cy08) fars09.person(in=cy09) fars10.person(in=cy10)
      fars11.person(in=cy11) fars12.person(in=cy12) fars13.person(in=cy13);

if cy98 then year=1998;
else if cy99 then year=1999; else if cy00 then year=2000; else if cy01 then
year=2001;
```

```
else if cy02 then year=2002; else if cy03 then year=2003; else if cy04 then
year=2004;
else if cy05 then year=2005; else if cy06 then year=2006; else if cy07 then
year=2007;
else if cy08 then year=2008; else if cy09 then year=2009; else if cy10 then
year=2010;
else if cy11 then year=2011; else if cy12 then year=2012; else if cy13 then
year=2013;

      if 11<=seat_pos <=19 then seat_c =1;
      else if 20<=seat_pos <=54 then seat_c =0;
      else seat_c =.;
      if sex =2 then sex_c =1;  /*female  */
      else sex_c =0;
if per_typ in (1,2,9)  OR per_TYPE in (1,2,9);          /* driver and
passenger */
run;
proc sort data=person_F;
by year  state st_case veh_no; run;

/*  ********** for  weight only Chapter 2 only *****************  */
data striking_CT_F_W;
set Fanalysis;
if body_C in (1,2,3,4) and (2000<=year <=2013);        /*  choose BODY_C  and
10 yearshere  */
                        /* vehicle maneuver  */
if year le 2008 and veh_man in (4,6,7,8,12, 13,14,15) then delete;
       /* keep 3=accelerat,10=right-turn,11=left turn?? */
else if year ge 2009 and p_crash1 in (0,4,5,7,8,9,12,13) then delete;
/* keep 3, 10, 11, 12  Update NOV 2015  */
if road_fnc in (1,2,11,12,13);                   /* inter state hwy  */
if impact2 in (11,12,1) OR impact1 in (11,12,1);    /* front damages  */
if (man_coll in (0,1,2,3,4,5,6,7) AND 2002<= year <=2013)
OR (man_coll in (0,1,2,4,5,6) AND year in (2000, 2001));
if harm_EV =51 or m_harm =51 or J_knife in (2,3) then jack_c =1; else
jack_c=0;
*if harm_EV =51 or m_harm =51 then jack_cc =1; else jack_cc=0;
run;
/* above wider definitions           */
/*  **************************************************  */

/*  step 6 striking  and choose Body_C for CT, SU or BUS !!!!!!!!!!!  */
/* for Chapters 2,3,4, from STRIKING_CT_G and same veh type
/*  choose veh striking type
                         &striking_C
********************  */
      *%LET striking_C = 1;     /* same as GES striking veh 1,2,3,4  */
data striking_CT_F;
set Fanalysis;
if body_C = &striking_C;
                                    /* vehicle maneuver  */
if year le 2008 and veh_man in (4,6,7,8,12, 13,14,15) then delete;
       /* keep 3=accelerat,10=right-turn,11=left turn?? */
else if year ge 2009 and p_crash1 in (0,4,5,7,8,9,12,13) then delete;
/* keep 3, 10, 11, 12  Update NOV 2015  */
if road_fnc in (1,2,11,12,13);                   /* inter state hwy  */
if impact2 in (11,12,1) OR impact1 in (11,12,1);    /* front damages  */
```

```
if (man_coll in (0,1,2,3,4,5,6,7) AND 2002<= year <=2013)
OR (man_coll in (0,1,2,4,5,6) AND year in (2000, 2001));
run;

/*  FARS analytic persons associated with crash by striking veh only
**************  */

data fanalysis_per;           /* from striking Veh and Body_C  */
merge striking_CT_F(in=a) person_F(in=b);
by year  state st_case;
if a and b;
      if rest_use in (0,7) then belt_c =1;        /* not used  */
      else if rest_use in (1,2,3,4,5,6,8,10,11,12,13) then belt_c=0;  /*use
belt  */
      else belt_c=.;  /* missing or unknown  */            /* use belt  */

if inj_sev in (4,6) then fatal_c=1;
else fatal_C=0;

if spltype=4 then speed2=rannor(123) * 4 + 64.2;              /* M-B file
mean and standard error  */
else if spltype=5 then speed2=rannor(1234) * 4 + 65.5;
else if spltype=6 then speed2=rannor(12345) * 3.69 + 66.7;
else if spltype=7 then speed2=rannor(123456) * 4.55 + 68.6;
else if spltype=8 then speed2=rannor(1234567) * 5.63 + 72.3;
/*  means ONLY  ***************  */
if spltype =4 then speed3=64.2;
else if spltype=5 then speed3=65.5;            /* mean value only  */
else if spltype=6 then speed3=66.7;
else if spltype=7 then speed3=68.6;
else if spltype=8 then speed3=72.3;
                     /* new travel speed from Markus  */
if spltype=4 then speed4=rannor(123) * 3.52 + 62.07;          /* mean and
standard error  */
else if spltype=5 then speed4=rannor(1234) * 3.05 + 63.46;
else if spltype=6 then speed4=rannor(12345) * 3.77 + 66.63;
else if spltype=7 then speed4=rannor(123456) * 4.00 + 68.90;
else if spltype=8 then speed4=rannor(1234567) * 4.48 + 68.34;

if 1<=splTYPE <=9 and (2000<= year <=2013);
run;

/* add person FARs   */
/* save FARS data */
data limiter.FARS_ACC_VEH_98_12; set Fanalysis; run;
data limiter.FARS_ACC_VEH_per98_12; set Fanalysis_per; run;

/* step 7  merge FARS and GES  together    */
/* ****************************************************************  */
/* crashed vehicles!!  GES and FARS  */

data analysis;                   /* vehicle based  */
drop state st_case casenum sp_limit vspd_lim;
set striking_CT_G (in=inj) striking_CT_F (in=fat);              /* use GES
and FARS  */
if fat then fatal_V=1;                /* nominator  */
```

```
else if (inj and maxsev NE 4) then fatal_V =0;
/* denominator  */
      if spltype=4 then speed2=rannor(123) * 4 + 64.2;              /* mean
and standard error  */
      else if spltype=5 then speed2=rannor(1234) * 4 + 65.5;
      else if spltype=6 then speed2=rannor(12345) * 3.69 + 66.7;
      else if spltype=7 then speed2=rannor(123456) * 4.55 + 68.6;
      else if spltype=8 then speed2=rannor(1234567) * 5.63 + 72.3;

      if 20<= speed2 <=30 then speed2_c =1;
      else if 31<= speed2 <=40 then speed2_c =2;
      else if 41<= speed2 <=50 then speed2_c =3;
      else if 51<= speed2 <=55 then speed2_c =4;
      else if 56<= speed2 <=60 then speed2_c =5;
      else if 61<= speed2 <=65 then speed2_c =6;
      else if 66<= speed2 <=70 then speed2_c =7;
      else if 71<= speed2 <=75 then speed2_c =8;
      else if 76<= speed2 <=80 then speed2_c =9;
      else speed2_c =.;

      /*  means ONLY  ****************  */
      if spltype=4 then speed3=64.2;
      else if spltype=5 then speed3=65.5;            /* mean value only  */
      else if spltype=6 then speed3=66.7;
      else if spltype=7 then speed3=68.6;
      else if spltype=8 then speed3=72.3;

if spltype=4 then speed4=rannor(123) * 3.52 + 62.07;              /* Markus
mean and standard error  */
else if spltype=5 then speed4=rannor(1234) * 3.05 + 63.46;
else if spltype=6 then speed4=rannor(12345) * 3.77 + 66.63;
else if spltype=7 then speed4=rannor(123456) * 4.00 + 68.90;
else if spltype=8 then speed4=rannor(1234567) * 4.48 + 68.34;

if spltype=4 then speed4m = 62.07;         /* Markus mean and standard error
*/
else if spltype=5 then speed4m = 63.46;
else if spltype=6 then speed4m = 66.63;
else if spltype=7 then speed4m = 68.90;
else if spltype=8 then speed4m = 68.34;

      if 20<= speed4 <=30 then speed4_c =1;
      else if 31<= speed4 <=40 then speed4_c =2;
      else if 41<= speed4 <=50 then speed4_c =3;
      else if 51<= speed4 <=55 then speed4_c =4;
      else if 56<= speed4 <=60 then speed4_c =5;
      else if 61<= speed4 <=65 then speed4_c =6;
      else if 66<= speed4 <=70 then speed4_c =7;
      else if 71<= speed4 <=75 then speed4_c =8;
      else if 76<= speed4 <=80 then speed4_c =9;
      else speed4_c =.;

if 1< =spltype <=9 AND 2000 <=year <=2013;
run;

proc contents data=analysis; run;
/* crashed CT FARS /over GES  */
```

```
/* step 7 ********* Occupants from GES and FARS together ************* */

data analysis_PER;
drop state st_case casenum sp_limit vspd_lim;
set Ganalysis_PER (in=a) fanalysis_PER (in=b);            /* use GES and FARS
*/
if (b and inj_SEV in (4,6)) then fatal_CC =1;               /* nominator  */
else if ( a and inj_SEV not in (4,6)) then fatal_CC =0;
/* denominator  */

      if spltype=4 then speed2=rannor(123) * 4 + 64.2;
                              /* mean and standard error  */
      else if spltype=5 then speed2=rannor(1234) * 4 + 65.5;
      else if spltype=6 then speed2=rannor(12345) * 3.69 + 66.7;
      else if spltype=7 then speed2=rannor(123456) * 4.55 + 68.6;
      else if spltype=8 then speed2=rannor(1234567) * 5.63 + 72.3;

      if 20<= speed2 <=30 then speed2_c =1;
      else if 31<= speed2 <=40 then speed2_c =2;
      else if 41<= speed2 <=50 then speed2_c =3;
      else if 51<= speed2 <=55 then speed2_c =4;
      else if 56<= speed2 <=60 then speed2_c =5;
      else if 61<= speed2 <=65 then speed2_c =6;
      else if 66<= speed2 <=70 then speed2_c =7;
      else if 71<= speed2 <=75 then speed2_c =8;
      else if 76<= speed2 <=80 then speed2_c =9;
      else speed2_c =.;

      /*  means ONLY  ****************  */
      if spltype =4 then speed3=64.2;
      else if spltype=5 then speed3=65.5;            /* mean value only  */
      else if spltype=6 then speed3=66.7;
      else if spltype=7 then speed3=68.6;
      else if spltype=8 then speed3=72.3;

if spltype=4 then speed4=rannor(123) * 3.52 + 62.07;         /* Markus mean
and standard error  */
else if spltype=5 then speed4=rannor(1234) * 3.05 + 63.46;
else if spltype=6 then speed4=rannor(12345) * 3.77 + 66.63;
else if spltype=7 then speed4=rannor(123456) * 4.00 + 68.90;
else if spltype=8 then speed4=rannor(1234567) * 4.48 + 68.34;

if spltype=4 then speed4m = 62.07;              /* Markus mean and standard
error  */
else if spltype=5 then speed4m = 63.46;
else if spltype=6 then speed4m = 66.63;
else if spltype=7 then speed4m = 68.90;
else if spltype=8 then speed4m = 68.34;

      if 20<= speed4 <=30 then speed4_c =1;
      else if 31<= speed4 <=40 then speed4_c =2;
      else if 41<= speed4 <=50 then speed4_c =3;
      else if 51<= speed4 <=55 then speed4_c =4;
      else if 56<= speed4 <=60 then speed4_c =5;
      else if 61<= speed4 <=65 then speed4_c =6;
      else if 66<= speed4 <=70 then speed4_c =7;
```

```
      else if 71<= speed4 <=75 then speed4_c =8;
      else if 76<= speed4 <=80 then speed4_c =9;
      else speed4_c =.;

if 1 <= splTYPE <=9 AND 2000 <=year <=2013;
run;

/*  step 8 belt use rate in GES adjustment   */
/*  trying to reduce belt use in GES 90% to 75%, or 77% or 85%, by randomly
selecting a small percentage of GES belt-users and turn this small part
'user' to 'non-user', so that the overall belt rate is lower in GES
*************  */

data belt_rd75;
set ganalysis_per;
      if belt_c NE 0 then do;        /* not-use belt or umknown  */
      output;
      end;
      else if belt_c = 0 then do;                /* use belt of 75% */
            random_int = int(ranuni(0) * 30000 + 1);
            if belt_c =0 and 1<= random_int <4975 then belt_c =1;
                                /* switch to not-use  */
      output;
      end;
run;
proc freq data= belt_rd75;
tables splTYPE * belt_c /missing norow nocol;
weight ratWGT;
where 1<= splTYPE <=9 and 2004<= year<= 2013;
run;

data belt_rd77;
set ganalysis_per;
      if belt_c NE 0 then do;          /* not-use belt or umknown  */
      output;
      end;
      else if belt_c = 0 then do;                /* use belt  about 77%*/
            random_int = int(ranuni(0) * 30000 + 1);
            if belt_c =0 and 1<= random_int <4500 then belt_c =1;   /* switch
to not-use  */
      output;
      end;
run;
proc freq data= belt_rd77;
tables splTYPE * belt_c /missing norow nocol;
weight ratWGT;
where 1<= splTYPE <=9 and 2004<= year<= 2013;
run;

data belt_rd85;
set ganalysis_per;
      if belt_c NE 0 then do;          /* not-use belt or umknown  */
      output;
      end;
      else if belt_c = 0 then do;                /* use belt  about 77%*/
            random_int = int(ranuni(0) * 30000 + 1);
```

```
            if belt_c =0 and 1<= random_int <1700 then belt_c =1;   /* switch
to not-use  */
      output;
      end;
run;
proc freq data= belt_rd85;
tables splTYPE * belt_c /missing norow nocol;
weight ratWGT;
where 1<= splTYPE <=9 and 2004<= year<= 2013;
run;

/*  trying to reduce belt use in GES 90% to 77%  **************  */
proc freq data= ganalysis_per;
tables splTYPE * belt_c /missing;
weight ratWGT;
where 1<= splTYPE <=9 and 2004<= year<= 2013;
run;

/*  trying to reduce belt use GES only 75% **************  */

data analysis_PER75;
drop state st_case casenum sp_limit vspd_lim;
set belt_rd75 (in=a) fanalysis_PER (in=b);              /* use GES and FARS
*/
if (b and inj_SEV in (4,6)) then fatal_CC =1;
/* nominator  */
else if ( a and inj_SEV not in (4,6)) then fatal_CC =0;
/* denominator  */

      if spltype=4 then speed2=rannor(123) * 4 + 64.2;
                 /* mean and standard error  */
      else if spltype=5 then speed2=rannor(1234) * 4 + 65.5;
      else if spltype=6 then speed2=rannor(12345) * 3.69 + 66.7;
      else if spltype=7 then speed2=rannor(123456) * 4.55 + 68.6;
      else if spltype=8 then speed2=rannor(1234567) * 5.63 + 72.3;

      if 20<= speed2 <=30 then speed2_c =1;
      else if 31<= speed2 <=40 then speed2_c =2;
      else if 41<= speed2 <=50 then speed2_c =3;
      else if 51<= speed2 <=55 then speed2_c =4;
      else if 56<= speed2 <=60 then speed2_c =5;
      else if 61<= speed2 <=65 then speed2_c =6;
      else if 66<= speed2 <=70 then speed2_c =7;
      else if 71<= speed2 <=75 then speed2_c =8;
      else if 76<= speed2 <=80 then speed2_c =9;
      else speed2_c =.;
      /*  means ONLY  ****************  */
      if spltype =4 then speed3=64.2;
      else if spltype=5 then speed3=65.5;            /* mean value only  */
      else if spltype=6 then speed3=66.7;
      else if spltype=7 then speed3=68.6;
      else if spltype=8 then speed3=72.3;

if spltype=4 then speed4=rannor(123) * 3.52 + 62.07;              /* Markus
mean and standard error  */
else if spltype=5 then speed4=rannor(1234) * 3.05 + 63.46;
else if spltype=6 then speed4=rannor(12345) * 3.77 + 66.63;
```

```
else if spltype=7 then speed4=rannor(123456) * 4.00 + 68.90;
else if spltype=8 then speed4=rannor(1234567) * 4.48 + 68.34;

if spltype=4 then speed4m = 62.07;
                /* Markus mean and standard error  */
else if spltype=5 then speed4m = 63.46;
else if spltype=6 then speed4m = 66.63;
else if spltype=7 then speed4m = 68.90;
else if spltype=8 then speed4m = 68.34;

      if 20<= speed4 <=30 then speed4_c =1;
      else if 31<= speed4 <=40 then speed4_c =2;
      else if 41<= speed4 <=50 then speed4_c =3;
      else if 51<= speed4 <=55 then speed4_c =4;
      else if 56<= speed4 <=60 then speed4_c =5;
      else if 61<= speed4 <=65 then speed4_c =6;
      else if 66<= speed4 <=70 then speed4_c =7;
      else if 71<= speed4 <=75 then speed4_c =8;
      else if 76<= speed4 <=80 then speed4_c =9;
      else speed4_c =.;

if 1 <= splTYPE <=9 AND 2000 <=year <=2013;
run;

      /*  step 9 Target Population  target here  */
/*  !!!!!!!!!!!  CHAPTER 2  Target populations *******************  */
/*  !!!!!!!!!!!  CHAPTER 2  *******************  */
/*   ******** Rich TEXT Format of Three Methods ******************   */
/* overall size on 5 roads */
ODS LISTING CLOSE; RUN;
ODS RTF FILE="&DIR.veh_size_26K_LB_BUS_LBs_weight__mar4_Ratios2.&YR4..RTF"
BODYTITLE;

proc freq data = striking_CT_F_w;
tables body_c * wt_c /MISSING norow nocol nopercent;
*weight ratwgt;
title 'FARS crashed vehicles vs speed';
where 2004<=year <=2013 and road_FNC in (1,11,2,12,13) AND 1<= SPLtype<=9;
run;

proc freq data = striking_CT_F_W;
tables body_c*splTYPE * road_FNC /norow nocol nopercent;
weight ratwgt;
title 'FARS crashed vehicles vs speed and lab more than 26K';
where 2004<=year <=2013 and road_FNC in (1,11,2,12,13)
and 1<= SPLtype<=9 AND WT_C=3 AND Body_c in (1,2,3);
run;

/* verify  */
proc freq data = striking_CT_F;
tables body_c*splTYPE * road_FNC /norow nocol nopercent;
weight ratwgt;
title 'FARS crashed vehicles vs speed and lab more than 26K';
where 2004<=year <=2013 and road_FNC in (1,11,2,12,13)
and 1<= SPLtype<=9;                  *and Body_c in (1,2,3) and WT_c=3;
run;
/* verify  */
```

```
proc freq data = Fanalysis_per;
tables splTYPE * inj_SEV /norow nocol nopercent;
weight ratwgt;
title ' verify body_c=1 FARS person vs. roads mth 26K and persons';
where 2004<=year <=2013 and road_FNC in (1,11,2,12,13)
and 1<= SPLtype<=9;
run;
proc freq data = Fanalysis_per;
tables body_c * splTYPE * inj_SEV /norow nocol nopercent;
weight ratwgt;
title ' verify body_c=1 FARS person vs. roads mth 26K and persons';
where 2004<=year <=2013 and road_FNC in (1,11)
and 1<= SPLtype<=9;
run;

ODS _ALL_ CLOSE; RUN;
ODS LISTING; RUN;

/* check JACKknife  */
proc freq data = striking_CT_F_W;
tables body_C*J_KNIFE * RollOVER /MISSING norow nocol nopercent;
*weight ratwgt;
title 'FARS jacknife vs. rollover';
where 2004<=year <=2013 and road_FNC in (1,11,2,12,13)
AND 3<= SPLtype<=9 and body_C in (1,2,3);
run;

proc freq data = striking_CT_F_W;
tables body_C*J_KNIFE * RollOVER /MISSING norow nocol nopercent;
*weight ratwgt;
title 'FARS jacknife vs. rollover';
where 2004<=year <=2009 and road_FNC in (1,11,2,12,13)
AND 3<= SPLtype<=9 and body_C in (1,2,3);
run;
proc freq data = striking_CT_F_W;
tables body_C* jack_c * RollOVER /MISSING norow nocol nopercent;
*weight ratwgt;
title 'FARS jacknife vs. rollover';
where 2010<=year <=2014 and road_FNC in (1,11,2,12,13)
AND 3<= SPLtype<=9 and body_C in (1,2,3);
run;
ODS _ALL_ CLOSE; RUN;
ODS LISTING; RUN;

/*  !!!!!!!!!!!  CHAPTER 2 Summary of Target Populations ****************
*/
/*  &&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&  */
/*   ******** Rich TEXT Format of Three Methods ******************   */
/* overall size on 5 roads */
ODS LISTING CLOSE; RUN;
ODS RTF FILE="&DIR.veh_size_injury__feb23_Ratios2.&YR4..RTF" BODYTITLE;

proc freq data = Fanalysis_per;
tables splTYPE * inj_SEV  /norow nocol nopercent;
weight ratwgt;
title 'FARS person vs. roads';
where 2004<=year <=2013 and road_FNC in (1,11,2,12,13);
```

```
run;
proc freq data = Fanalysis_per;
tables splTYPE * inj_SEV  /norow nocol nopercent;
weight ratwgt;
title 'FARS person vs. roads';
where 2004<=year <=2013 and road_FNC not in (2,12,13);
run;
      /*  collision manners  and check ve target here  */
proc freq data = striking_CT_G;
tables splTYPE * max_sev /norow nocol nopercent;
weight ratwgt;
title 'GES crashed vehicles vs max injuries';
where 2004<=year <=2013 and int_HWY=1 and WT_C=3;
run;
proc freq data = Ganalysis_PER;
tables splTYPE * inj_SEV /norow nocol nopercent;
weight ratwgt;
title 'GES person vs  injuries';
where 2004<=year <=2013 and WT_C=3;
run;
ODS _ALL_ CLOSE; RUN;
ODS LISTING; RUN;

/*  ! step 10  CHAPTER 3 Veh crashes ********************  */

Consider speed limit, Mack_Blackwell Travel speed, and New Test Travel Speed
*/
/*   ******** Rich TEXT Format of Three Methods *******************   */
ODS LISTING CLOSE; RUN;
ODS RTF FILE="&DIR.FEB18b_crashed_bus_Veh26.&YR4..RTF" BODYTITLE;

proc freq data =analysis;
tables splTYPE * fatal_V;
weight ratwgt;
*title 'crashed vehicles vs speed';
where 2004<=year <=2013 and road_fnc not in (2,12,13);
run;

proc surveylogistic data=analysis;
/* add Nov 2, 2015 5 miles  */
where 3<= splTYPE <=8 and 2004 <= YEAR<=2013 and road_fnc not in (2,12,13);
model fatal_V (event='1') = spltype /clparm;
weight ratwgt;
cluster psu;
stratum psustrat;
title "HEAVY TRUCK Combination using Method  and Speed Limit 5 miles increase
";
output out=CT_limit5 p=pred l=lcl_pred  u=ucl_pred;
run;

proc surveylogistic data=analysis;
/* add Nov 2, 2015 5 miles  */
where 3<= splTYPE <=8 and 2004 <= YEAR<=2013 and road_fnc not in (2,12,13);
model fatal_V (event='1') = spltype lane_c road_c weather_c/clparm;
weight ratwgt;
cluster psu;
stratum psustrat;
```

```
title "HEAVY TRUCK Combination using Speed Limit 5 miles increase ";
output out=CT_limit5 p=pred l=lcl_pred  u=ucl_pred;
run;

proc surveylogistic data=analysis;
/* add Nov 2, 2015 5 miles  */
where 3<= splTYPE <=8 and 2004 <= YEAR<=2013 and road_fnc not in (2,12,13);
model fatal_V (event='1') = spltype road_c lane_c/clparm;
weight ratwgt;
cluster psu;
stratum psustrat;
title "HEAVY TRUCK Combination using Speed Limit 5 miles increase ";
output out=CT_limit5 p=pred l=lcl_pred  u=ucl_pred;
run;

/* M_B file 1 mile  */
proc surveylogistic data=analysis;
/* add Nov 2, 2015 5 miles  */
where 3<= splTYPE <=8 and 2004 <= YEAR<=2013 and road_fnc not in (2,12,13);
model fatal_V (event='1') = speed2 road_c lane_c/clparm;
weight ratwgt;
cluster psu;
stratum psustrat;
title "HEAVY TRUCK Combination using Method2 normal distribution 1 mi
increase ";
output out=CT_limit5 p=pred l=lcl_pred  u=ucl_pred;
run;
/* M_B file 1 mile using 5 points   */
proc surveylogistic data=analysis;
/* add Nov 2, 2015 5 miles  */
where 3<= splTYPE <=8 and 2004 <= YEAR<=2013
and road_fnc not in (2,12,13); *AND road_fnc in (1,11);
model fatal_V (event='1') = speed3 road_c lane_c/clparm;
weight ratwgt;
cluster psu;
stratum psustrat;
title "HEAVY TRUCK Combination using Method 3 means only ";
output out=CT_limit5 p=pred l=lcl_pred  u=ucl_pred;
run;
/* new travel speed 1 mile */
proc surveylogistic data=analysis;
/* add Nov 2, 2015 5 miles  */
where 3<= splTYPE <=8 and 2004 <= YEAR<=2013
and road_fnc not in (2,12,13);
model fatal_V (event='1') = speed4 /clparm;
weight ratwgt;
cluster psu;
stratum psustrat;
title "HEAVY TRUCK Combination using NEW 1 m9ile ONE VAR only ";
output out=CT_limit5 p=pred l=lcl_pred  u=ucl_pred;
run;

proc surveylogistic data=analysis;
/* add Nov 2, 2015 5 miles  */
where 3<= splTYPE <=8 and 2004 <= YEAR<=2013
and road_fnc not in (2,12,13);
model fatal_V (event='1') = speed4 road_c lane_c/clparm;
```

```
weight ratwgt;
cluster psu;
stratum psustrat;
title "HEAVY TRUCK Combination using Method 3 means only ";
output out=CT_limit5 p=pred l=lcl_pred  u=ucl_pred;
run;

proc surveylogistic data=analysis;
/* add Nov 2, 2015 5 miles  */
where 3<= splTYPE <=8 and 2004 <= YEAR<=2013
and road_fnc not in (2,12,13);
model fatal_V (event='1') = speed4m road_c lane_c/clparm;
weight ratwgt;
cluster psu;
stratum psustrat;
title "HEAVY TRUCK Combination using Method 3 means only ";
output out=CT_limit5 p=pred l=lcl_pred  u=ucl_pred;
run;

proc surveylogistic data=analysis;
/* add Nov 2, 2015 5 miles  */
where 3<= splTYPE <=8 and 2004 <= YEAR<=2013
and road_fnc not in (2,12,13);
model fatal_V (event='1') = drive_V road_c lane_c/clparm;
weight ratwgt;
cluster psu;
stratum psustrat;
title "HEAVY TRUCK Combination using travel speed from database only ";
output out=CT_limit5 p=pred l=lcl_pred  u=ucl_pred;
run;
ODS _ALL_ CLOSE; RUN;
ODS LISTING; RUN;

/* step 10 Chapter 3 for PRIA Vehicle Crash new speed profiles **************
*/

ODS LISTING CLOSE; RUN;
ODS RTF FILE="&DIR.ANAlysis_PERSON_Ratios_March_SU10.&YR4..RTF" BODYTITLE;
proc surveylogistic data=analysis;
/* add Nov 2, 2015 5 miles  */
where 3<= splTYPE <=8 and 2004 <= YEAR<=2013
and road_fnc not in (2,12,13);
model fatal_V (event='1') = speed4 /clparm;
weight ratwgt;
cluster psu;
stratum psustrat;
title "HEAVY TRUCK Combination using NEW 1 m9ile ONE VAR only ";
output out=CT_limit5 p=pred l=lcl_pred  u=ucl_pred;
run;

proc surveylogistic data=analysis;
where 3<= splTYPE <=8 and 2004 <= YEAR<=2013
and road_fnc not in (2,12,13);
model fatal_V (event='1') = speed4 road_c lane_c/clparm;
weight ratwgt;
cluster psu;
stratum psustrat;
```

```
title "HEAVY TRUCK Combination using Method 3 means only ";
output out=CT_limit5 p=pred l=lcl_pred  u=ucl_pred;
run;

proc surveylogistic data=analysis;
where 3<= splTYPE <=8 and 2004 <= YEAR<=2013
and road_fnc not in (2,12,13);
model fatal_V (event='1') = speed4m road_c lane_c/clparm;
weight ratwgt;
cluster psu;
stratum psustrat;
title "HEAVY TRUCK Combination using Method 3 means only ";
output out=CT_limit5 p=pred l=lcl_pred  u=ucl_pred;
run;
ODS _ALL_ CLOSE; RUN;
ODS LISTING; RUN;

/*  Additional Study -  CHAPTER 4 , choose person-realted files  !!
Consider speed limit, Mack-Blackwell speed, New travel speed, */

            %LET input_PER = analysis_PER;          /* GES 90%  */
            %LET input_PER = analysis_PER75;
            %LET input_PER = analysis_PER77;
/*  &&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&  */
ODS LISTING CLOSE; RUN;
ODS RTF FILE="&DIR.ANAlysis_PERSON_Ratios_March3.&YR4..RTF" BODYTITLE;

proc freq data= Ganalysis_PER;
tables splTYPE * belt_c /missing norow nocol;
weight ratWGT;
where 1<= splTYPE <=9 and 2004<= year<= 2013;
title " original GES ONLY belt use rate";
run;

proc freq data= &input_PER;              /* 1st raw data Table */
tables splTYPE*belt_c /missing norow nocol;
weight ratwgt;
where 1<= splTYPE <=9 and 2004<=year<=2013 AND road_fnc not in (2,12,13);
/* CT only  restrict uears  */
title " GES and FARS belt use rate";
run;

proc surveylogistic data= &input_PER;
model fatal_CC (event='1') = splTYPE /clparm;
weight ratwgt;
cluster psu;
where 2004<= year <=2013 AND 3<= splTYPE <=8 AND road_fnc not in (2,12,13);
title "HEAVY TRUCK Combination using speed limit 5 Miles ";
output out=CT_norm5 p=pred l=lcl_pred  u=ucl_pred;
run;

proc surveylogistic data= &input_PER;
model fatal_CC (event='1') = splTYPE  belt_c/clparm;
weight ratwgt;
cluster psu;
where 2004<= year <=2013 AND 3<= splTYPE <=8 AND road_fnc not in (2,12,13);
title "HEAVY TRUCK Combination using speed limit 5 Miles ";
```

```
output out=CT_norm5 p=pred l=lcl_pred  u=ucl_pred;
run;

proc surveylogistic data= &input_PER;
model fatal_CC (event='1') = splTYPE belt_c age sex_c seat_c lane_c
road_c/clparm;
weight ratwgt;
cluster psu;
where 2004<= year <=2013 AND 3<= splTYPE <=8 AND road_fnc not in (2,12,13);
title "HEAVY TRUCK Combination using speed limit 5 Miles ";
output out=CT_norm5 p=pred l=lcl_pred  u=ucl_pred;
run;

/* method 2   discussion NOV 2 2015  Mack-Blackwell
proc surveylogistic data= &input_PER;
model fatal_CC (event='1') = speed2 belt_c age sex_c seat_c lane_c weather_c
road_c /clparm;
weight ratwgt;
cluster psu;
where 2004<= year <=2013 AND 3<= splTYPE <=8 AND road_fnc not in (2,12,13);
title "HEAVY TRUCK Combination using Method2 with only 1 mile increase";
output out=CT_norm5 p=pred l=lcl_pred  u=ucl_pred;
run;

/*  Normal distribution  */
proc surveylogistic data= &input_PER;
model fatal_CC (event='1') = speed3 belt_c age sex_c seat_c lane_c weather_c
road_c /clparm;
weight ratwgt;
cluster psu;
where 2004<= year <=2013 AND 3<= splTYPE <=8 AND road_fnc not in (2,12,13);
title "HEAVY TRUCK Combination using 5 points Method3 with only 1 mile
increase";
output out=CT_norm5 p=pred l=lcl_pred  u=ucl_pred;
run;
ODS _ALL_ CLOSE; RUN;
ODS LISTING; RUN;

/*  step 10 NEW Speed CHAPTER 4 ********************  */
/*  &&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&  */
ODS LISTING CLOSE; RUN;
ODS RTF FILE="&DIR.ANAlysis_PERSON_GES75_Ratios_March17BUS_per.&YR4..RTF"
BODYTITLE;
proc surveylogistic data= &input_PER;
model fatal_CC (event='1') = speed4 /clparm;
weight ratwgt;
cluster psu;
where 2004<= year <=2013 AND 3<= splTYPE <=8 AND road_fnc not in (2,12,13);
title " 1VAR HEAVY TRUCK Combination using Method3 with only 1 mile
increase";
output out=CT_norm5 p=pred l=lcl_pred  u=ucl_pred;
run;

proc surveylogistic data= &input_PER;
model fatal_CC (event='1') = speed4 belt_c age sex_c seat_c lane_c road_c
/clparm;
weight ratwgt;
```

```
cluster psu;
where 2004<= year <=2013 AND 3<= splTYPE <=8 AND road_fnc not in (2,12,13);
title " Distribution -HEAVY TRUCK Combination using Method3 with only 1 mile
increase";
output out=CT_norm5 p=pred l=lcl_pred  u=ucl_pred;
run;

proc surveylogistic data= &input_PER;
model fatal_CC (event='1') = speed4m belt_c age sex_c seat_c lane_c road_c
/clparm;
weight ratwgt;
cluster psu;
where 2004<= year <=2013 AND 3<= splTYPE <=8 AND road_fnc not in (2,12,13);
title "5 points -HEAVY TRUCK Combination using Method3 with only 1 mile
increase";
output out=CT_norm5 p=pred l=lcl_pred  u=ucl_pred;
run;
ODS _ALL_ CLOSE; RUN;
ODS LISTING; RUN;
```

Appendix I. Potential benefits of limiting the maximum allowable speed to 68 mph and 60 mph.

Speed limit set at 68 mph:

Using the same methodology as that used to calculate the safety benefits of limiting heavy vehicles to 65 mph, we estimate that limiting heavy vehicles to 68 mph would save a total of 27 - 96 lives, annually. Among the 27 - 96 lives saved, approximately 96% of all lives saved would be from combination truck speeding crashes.[132]

Table 1
Percent reduction in fatal crash rate if combination truck speeds are limited to 68 mph with 68 mph speed limiting device, vehicle-based approach with an odds ratio of 1.047

Travel speed, mph	Increase in odds	%-reduction in odds
68	1.000000	0.0000
69	1.047000	0.0449
70	1.096209	0.0878
71	1.147731	0.1287
72	1.201674	0.1678
73	1.258153	0.2052
74	1.317286	0.2409
75	1.379198	0.2749
76	1.444021	0.3075
77	1.511890	0.3386
78	1.582949	0.3683
79	1.657347	0.3966
80	1.735243	0.4237
81	1.816799	0.4496
82	1.902188	0.4743
83	1.991591	0.4979
84	2.085196	0.5204
85	2.183200	0.5420

[132] With 68 mph speed limiting devices, we expect 27 - 92 lives would be saved in combination trucks crashes. For SUTs and buses, 1 - 2 and 1-2 lives, respectively would be saved with 68 mph speed limiting devices.

Table 2 Percent reduction in fatal crash rate if single unit truck speeds are limited to 68 mph with 68 mph speed limiting device, with vehicle-based approach with an odds ratio of 1.014

Travel speed, mph	Increase in odds	%-reduction in odds
68	1.00000	0.0000
69	1.01400	0.0138
70	1.02820	0.0274
71	1.04259	0.0409
72	1.05719	0.0541
73	1.07199	0.0672
74	1.08700	0.0800
75	1.10221	0.0927
76	1.11764	0.1053
77	1.13329	0.1176
78	1.14916	0.1298
79	1.16525	0.1418
80	1.18156	0.1537
81	1.19810	0.1653
82	1.21487	0.1769
83	1.23188	0.1882
84	1.24913	0.1994
85	1.26662	0.2105

Table 3 Percent reduction in fatal crash rate if bus speeds are limited to 68 mph with 68 mph speed limiting device, with person-based approach with an odds ratio of 1.024

Travel speed, mph	Increase in odds	%-reduction in odds
68	1.00000	0.0000
69	1.02400	0.0234
70	1.04858	0.0463
71	1.07374	0.0687
72	1.09951	0.0905
73	1.12590	0.1118
74	1.15292	0.1326
75	1.18059	0.1530
76	1.20893	0.1728
77	1.23794	0.1922
78	1.26765	0.2111
79	1.29807	0.2296
80	1.32923	0.2477
81	1.36113	0.2653
82	1.39380	0.2825
83	1.42725	0.2994
84	1.46150	0.3158

85	1.49658	0.3318

Table 4. Summary of lives saved with speed limiter

Speed Limiter	Vehicle		Lives saved by odds ratio & vehicle type					
			Vehicle-based			Person-based		
68 mph	Combination truck	Odds ratio	1.047	1.058	1.154	1.033	1.046	1.150
		Lives saved	36	43	92	27	36	91
	SUT	Odds ratio	1.014	1.079	1.053	1.035	1.097	1.068
		Lives saved	0.3	1.5	1.1	1	1.8	1.4
	Bus	Odds ratio	1	1.081	1.12	1.024	1.165	1.098
		Lives saved	0	1	1.3	0.5	2.2	1.5

Like the a 65 mph speed limiting device, requiring a 68 mph speed limiting device would result in a longer delivery or travel time for the same distance traveled if a vehicle was previously traveling at speeds greater than 68 mph. For the 68 mph speed limiting device, based on the observed state data, we estimated that the overall time lost would be 18 million hours. Among the 18 million hours, 16 million hours would be from combination trucks. In other words, when the speed of combination trucks is limited to 68 mph, the time to cover the same distance would increase by 1.3% when compared with the baseline 1,250 million hours without a speed limiting device.

Table 5. Baseline VMT distribution and travel time

Travel speed, mph	Baseline VMT						
	55 MPH	60 MPH	65 MPH	70 MPH	75 MPH	Total VMT	Mil Hrs
	20,848	11,472	20,447	18,970	10,041	81,778	
45	0.02	0.00	0.00	0.00	0.00	0.02	0.00
46	0.07	0.00	0.00	0.00	0.00	0.08	0.00
47	0.25	0.00	0.00	0.00	0.01	0.27	0.01
48	0.81	0.00	0.01	0.00	0.03	0.86	0.02
49	2.43	0.02	0.04	0.01	0.08	2.57	0.05
50	6.69	0.09	0.13	0.03	0.20	7.14	0.14
51	16.98	0.37	0.39	0.09	0.50	18.32	0.36
52	39.79	1.32	1.14	0.26	1.15	43.66	0.84
53	86.02	4.26	3.09	0.71	2.53	96.62	1.82
54	171.55	12.39	7.81	1.86	5.30	198.91	3.68
55	315.65	32.37	18.37	4.57	10.56	381.51	6.94
56	535.81	75.96	40.25	10.54	20.04	682.60	12.19

57	839.13	160.13	82.22	22.84	36.17	1140.49	20.01
58	1212.42	303.28	156.51	46.52	62.10	1780.83	30.70
59	1616.15	516.01	277.67	88.99	101.45	2600.27	44.07
60	1987.54	788.76	459.08	159.94	157.67	3553.00	59.22
61	2255.05	1083.18	707.37	270.09	233.13	4548.83	74.57
62	2360.49	1336.35	1015.79	428.50	327.94	5469.07	88.21
63	2279.58	1481.18	1359.41	638.70	438.87	6197.75	98.38
64	2031.01	1474.89	1695.50	894.45	558.76	6654.60	103.98
65	1669.45	1319.40	1970.77	1176.83	676.80	6813.26	104.82
66	1266.03	1060.38	2134.87	1454.71	779.91	6695.90	101.45
67	885.76	765.62	2155.26	1689.46	855.02	6351.12	94.79
68	571.74	496.63	2027.80	1843.40	891.77	5831.33	85.75
69	340.47	289.41	1778.05	1889.73	884.86	5182.52	75.11
70	187.06	151.52	1452.97	1820.05	835.31	4446.90	63.53
71	94.81	71.27	1106.54	1646.92	750.18	3669.71	51.69
72	44.34	30.11	785.36	1400.12	640.96	2900.89	40.29
73	19.13	11.43	519.48	1118.31	521.01	2189.36	29.99
74	7.61	3.90	320.23	839.20	402.91	1573.85	21.27
75	2.80	1.19	183.97	591.66	296.43	1076.05	14.35
76	0.95	0.33	98.50	391.91	207.48	699.16	9.20
77	0.30	0.08	49.15	243.90	138.16	431.58	5.60
78	0.09	0.02	22.86	142.60	87.52	253.08	3.24
79	0.02	0.00	9.90	78.33	52.75	141.02	1.79
80	0.01	0.00	4.00	40.43	30.25	74.68	0.93
81	0.00	0.00	1.51	19.60	16.50	37.61	0.46
82	0.00	0.00	0.53	8.93	8.56	18.02	0.22
83	0.00	0.00	0.17	3.82	4.23	8.22	0.10
84	0.00	0.00	0.05	1.54	1.99	3.58	0.04
85	0.00	0.00	0.01	0.58	0.89	1.48	0.02
CT total VMT, in millions						81,778	
CT total hours, in millions							1249.84

Table 6. VMT distribution and travel time with 68 mph speed limiter

Travel speed, mph	68 MPH SL VMT						
	55 MPH	60 MPH	65 MPH	70 MPH	75 MPH	Total VMT	Mil Hrs
45	0.02	0.00	0.00	0.00	0.00	0.02	0.00
46	0.07	0.00	0.00	0.00	0.00	0.08	0.00
47	0.25	0.00	0.00	0.00	0.01	0.27	0.01
48	0.81	0.00	0.01	0.00	0.03	0.86	0.02
49	2.43	0.02	0.04	0.01	0.08	2.57	0.05
50	6.69	0.09	0.13	0.03	0.20	7.14	0.14
51	16.98	0.37	0.39	0.09	0.50	18.32	0.36

52	39.79	1.32	1.14	0.26	1.15	43.66	0.84
53	86.02	4.26	3.09	0.71	2.53	96.62	1.82
54	171.55	12.39	7.81	1.86	5.30	198.91	3.68
55	315.65	32.37	18.37	4.57	10.56	381.51	6.94
56	535.81	75.96	40.25	10.54	20.04	682.60	12.19
57	839.13	160.13	82.22	22.84	36.17	1140.49	20.01
58	1212.42	303.28	156.51	46.52	62.10	1780.83	30.70
59	1616.15	516.01	277.67	88.99	101.45	2600.27	44.07
60	1987.54	788.76	459.08	159.94	157.67	3553.00	59.22
61	2255.05	1083.18	707.37	270.09	233.13	4548.83	74.57
62	2360.49	1336.35	1015.79	428.50	327.94	5469.07	88.21
63	2279.58	1481.18	1359.41	638.70	438.87	6197.75	98.38
64	2031.01	1474.89	1695.50	894.45	558.76	6654.60	103.98
65	1669.45	1319.40	1970.77	1176.83	676.80	6813.26	104.82
66	1266.03	1060.38	2134.87	1454.71	779.91	6695.90	101.45
67	885.76	765.62	2155.26	1689.46	855.02	6351.12	94.79
68	1269.31	1055.89	8361.07	12081.04	5771.74	28539.06	419.69
CT total VMT, in millions						81,778	
CT total hours, in millions							1265.95

Table 7
Delay in delivery hours with 68 mph speed limiters, in millions

Vehicle	Hours, in M's
Combination truck	16
SUT	2
Bus	0.4
Total	18

Similar to the approach used for the proposed 65 mph speed limiter, we estimated societal costs associated with opportunity lost and inventory delay. The total costs with the alternative 68 mph speed limiting device were estimated to be $181 million, discounted at 7%.

Table 8. Heavy vehicles, with 68 mph speed limiter, societal costs associated with the delay in delivery time, in M's, 2013 dollars

Cost	CT		SUT		Bus		Total	
	3%	7%	3%	7%	3%	7%	3%	7%
Opportunity	$228.2	$181.2	$25.1	$19.9	$5.8	$4.6	$259.1	$205.7
Inventory	$4.3	$3.4	$0.3	$0.2	$0	$0	$4.6	$3.6
Total societal cost	$232.5	$184.6	$25.4	$20.1	$5.8	$4.6	$263.7	$209.3

Table 9 Fleet costs to hire new drivers with 68 mph speed limiter

Scenario	CT		SUT		Bus		Total	
	3%	7%	3%	7%	3%	7%	3%	7%
1	$1.2	$1.0	$0.13	$0.11	$0.03	$0.02	$1.36	$1.13
2	$66.5	$52.8	$7.3	$5.8	$0.03	$0.02	$73.83	$59.62

The benefits and net benefits for combination trucks, SUTs and buses are shown below:

Table 10 Combination trucks, lives saved, 68 mph speed limiters

CT	Vehicle-based			Person-based		
Odds ratio	1.047	1.058	1.154	1.033	1.046	1.150
Lives saved	36	43	92	27	36	91

Table 11 SUTs, lives saved, 68 mph speed limiters

SUT	Vehicle-based			Person-based		
Odds ratio	1.014	1.079	1.053	1.035	1.097	1.068*
Lives saved	0	1.5	1.1	1	1.8	1.4

Table 12 Buses, lives saved, 68 mph speed limiters

Bus	Vehicle-based			Person-based		
Odds ratio	0.996	1.081	1.12	1.024	1.165	1.098
Lives saved	0	1	1.3	0.5	2.2	1.5

For the expected fuel saving with a 68 mph speed limiting device, similar to the method used in the fuel saving estimate in the benefit chapter, we estimated that a 68 mph speed limiting device would result in 153 million gallons of fuel saving, annually, with a saving of $316 million discounted at 7%.

Table 13
Estimated fuel savings with 68 mph speed limiting device, pre-tax, in 2013 dollars

Vehicle	Gallons (M gal.)	Saving ($M)		
		No-discount	3% discounted	7% discounted
CT	136	$440	$356	$283
SUT	13	$41	$34	$27
Bus	3	$11	$9	$7
Total	153	$492	$398	$316

Table 14
Estimated fleet fuel savings with 68 mph speed limiting device, after-tax, in 2013 dollars

Vehicle	Gallons (M gal.)	Saving ($M)		
		No-discount	3% discounted	7% discounted
CT	136	$498	$403	$320
SUT	13	$47	$38	$30
Bus	3	$12	$10	$8
Total	153	$557	$451	$358

The net benefits with 68 mph speed limiters are shown below:

Table 15
Net benefits for combination trucks, with 68 mph speed limiter (in 2013 dollars, in millions)

CT			Vehicle-based			Person-based		
Odds Ratio			1.047	1.058	1.154	1.033	1.046	1.150
Benefit	Safety& Property	3%	$513	$615	$1,303	$378	$509	$1,293
		7%	$413	$495	$1,048	$304	$409	$1,040
	Fuel & GHG	3%	$423	$423	$423	$423	$423	$423
		7%	$336	$336	$336	$336	$336	$336
	Total benefit	3%	$936	$1,038	$1,726	$801	$932	$1,716
		7%	$749	$831	$1,384	$640	$745	$1,376
Cost		3%	$232	$232	$232	$232	$232	$232
		7%	$185	$185	$185	$185	$185	$185
Net Benefit		3%	$704	$806	$1,494	$569	$700	$1,484
		7%	$564	$646	$1,199	$455	$560	$1,191

Table 16. Net benefits for SUTs, with 68 mph speed limiter, in M's, 2013 dollars

SUT			Vehicle-based			Person-based		
Odds Ratio			1.014	1.079	1.053	1.035	1.097	1.068
Benefit	Safety& Property	3%	$4.5	$22	$15	$11.0	$26	$20
		7%	$3.6	$17	$12	$8.8	$21	$16
	Fuel & GHG	3%	$41	$41	$41	$41	$41	$41
		7%	$32	$32	$32	$32	$32	$32
	Total benefit	3%	$45	$63	$56	$52	$67	$61
		7%	$36	$49	$44	$41	$53	$48
Cost		3%	$25	$25	$25	$25	$25	$25
		7%	$20	$20	$20	$20	$20	$20
Net Benefit		3%	$20	$37	$31	$27	$42	$35
		7%	$15	$29	$24	$21	$33	$28

Table 17. Net benefits for Buses, with 68 mph speed limiter, in M's, in 2013 dollars

Bus			Vehicle-based			Person-based		
Odds Ratio			0.996	1.081	1.12	1.024	1.165	1.098
Benefit	Safety& Property	3%	$0	$15	$19	$6	$30	$22
		7%	$0	$12	$16	$5	$24	$17

	Fuel & GHG	3%	$11	$11	$11	$11	$11	$11
		7%	$8	$8	$8	$8	$8	$8
	Total benefit	3%	$11	$26	$30	$17	$41	$33
		7%	$8	$20	$24	$13	$32	$25
Cost		3%	$6	$6	$6	$6	$6	$6
		7%	$5	$5	$5	$5	$5	$5
Net Benefit		3%	$5	$20	$24	$11	$35	$27
		7%	$3	$15	$19	$8	$27	$21

Speed limit set at 60 mph:

In addition to the benefit estimates for speed limiting devices set at 65 mph and 68 mph, we estimated the potential safety benefit of a speed limiting device set at 60 mph. The benefit estimate method used for 65 mph and 68 mph speed limiting devices relies on the average heavy vehicle travel speed on roads with various posted speed limits (e.g., 55 mph, 60 mph, 65 mph, 70 mph, and 75 mph) and the risk of a crash resulting in a fatality versus an injury. The travel speed data shows that the average travel speeds for heavy vehicles on these roads are between 62 mph (55 mph roads) and 69 mph (70 mph roads) depending on the speed limit of the road. Therefore no data point exists near 60 mph.

Requiring a 60 mph speed limiting device would result in a longer delivery or travel time for the same distance traveled if a vehicle was previously traveling at speeds greater than 60 mph. For the 60 mph speed limiting device, we estimated that the overall time lost would be 137 (136.6) million hours. Among the 137 million hours, 118 million hours would be from combination trucks.

Table 18

Delay in delivery hours with 60 mph speed limiters, in millions

Vehicle	Hours, in M's
Combination truck	118
SUT	15
Bus	3.6
Total	136.6

Although we believe that the 60 mph alternative would result in additional safety benefits, we are not able to quantify the 60 mph alternative with the same confidence as the 65 mph proposal and 68 mph alternative. Nevertheless, the analysis shows that limiting vehicles to 60 mph would save 213 - 498 lives annually.

Table 19. Summary of lives saved with speed limiter

Speed Limiter	Vehicle		Lives saved by odds ratio & vehicle type					
			Vehicle-based			Person-based		
60 mph	Combination truck	Odds ratio	1.047	1.058	1.154	1.033	1.046	1.150
		Lives saved	213	251	472	159	210	466
	SUT	Odds ratio	1.014	1.079	1.053	1.035	1.097	1.068
		Lives saved	3	12	9	6	14	11
	Bus	Odds ratio	1	1.081	1.12	1.024	1.165	1.098
		Lives saved	0	6	8	3	12	9

The societal costs associated with increased travel times were estimated to be $1,580 million, discounted at 7% as shown below, using the same method that was used to calculate the costs for the proposed 65 mph and the alternative 68 mph speed limiting device.

Table 20. Heavy vehicles, with 60 mph speed limiter, societal costs associated with the delay in delivery time, in M's, 2013 dollars

Cost	CT		SUT		Bus		Total	
	3%	7%	3%	7%	3%	7%	3%	7%
Opportunity	$1,672.1	$1,327.6	$208.1	$165.2	$51.1	$40.6	$1,931.3	$1,533.4
Inventory	$31.5	$25.0	$2.3	$1.8	$0	$0	$33.8	$26.8
Total societal cost	$1,703.6	$1,352.6	$210.4	$167.0	$51.1	$40.6	$1,965.1	$1,580.2

Table 21 Fleet costs to hire new drivers with 60 mph speed limiter

Scenario	CT		SUT		Bus		Total	
	3%	7%	3%	7%	3%	7%	3%	7%
1	$413.5	$328.3	$51.4	$40.8	$11.9	$9.5	$476.8	$378.6
2	$2,205.8	$1,751.3	$75.7	$60.1	$11.9	$9.5	$2,293.4	$1,820.9

For fuel savings with a 60 mph speed limiting device, because the medium- and heavy-duty fuel economy rule accounted for the fuel savings from using speed limiting devices to limit the speed of heavy vehicles from 65 mph to a lower speed, no additional fuel savings from limiting heavy vehicle speeds below 65 mph are estimated. No additional fuel savings from a set speed below 65 mph could be attributed to this rulemaking without double-counting the benefits of the heavy-duty vehicle fuel efficiency program. Specifically, assuming that vehicle manufacturers design their speed limiting devices so that the devices also meet the necessary requirements to be used for compliance with the medium- and heavy-duty vehicle fuel efficiency program (which the agencies expect they will),[133] the fuel savings resulting from this rulemaking would be maximized with a set speed of 65 mph because the additional fuel savings for set speeds below 65 mph were accounted for in the heavy vehicle fuel efficiency program final rule.[134]

Under the medium- and heavy-duty vehicle fuel efficiency program, heavy vehicle drive cycles are evaluated at a maximum speed of 65 mph,[135] and a speed limiting device with a setting at or above 65 mph will show no fuel savings.[136] Thus, any fuel savings associated with speed settings of 65 mph and above were not estimated in the fuel efficiency program rulemaking. However, fuel efficiency evaluation under the program would reflect the difference in fuel consumption between the 65 mph baseline and a speed limiting device with a set speed below 65 mph,[137] and the heavy-duty vehicle fuel efficiency final rule has already accounted for the fuel

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[133] 40 CFR 1037.640.
[134] 76 FR 57106 (Sep. 15, 2011).
[135] 76 FR 57182; Final Rulemaking to Establish Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles, Regulatory Impact Analysis, Section 4.2.4, EPA-420-R-11-901
(August 2011), available at http://www nhtsa.gov/fuel-economy.
[136] 75 FR at 57155.
[137] Id.

savings resulting from this difference. Accordingly, no additional fuel savings from a set speed below 65 mph could be attributed to this rulemaking without double counting the benefits of the heavy-duty vehicle fuel efficiency program.

Based on the foregoing, the effective fuel savings with a 60 mph speed limiting device was estimated to be 344 million gallons (equivalent to the estimated fuel savings with a 65 mph speed limiting device.) When the heavy vehicle fuel efficiency is not considered, the effective fuel savings with a 60 mph speed limiting device would be 863 million gallons.[138]

<u>The net benefits with 60 mph speed limiters are shown below:</u>

Table 22
Net benefits for combination trucks, with 60 mph speed limiter (in 2013 dollars, in millions)

CT			Vehicle-based			Person-based		
Odds Ratio			1.047	1.058	1.154	1.033	1.046	1.150
Benefit	Safety& Property	3%	$3,027	$3,567	$6,695	$2,291	$2,615	$5,695
		7%	$2,434	$2,868	$5,382	$1,819	$2,112	$4,588
	Fuel & GHG	3%	$947	$947	$947	$947	$947	$947
		7%	$752	$752	$752	$752	$752	$752
	Total benefit	3%	$3,974	$4,514	$7,642	$2,960	$3,562	$6,642
		7%	$3,186	$3,620	$6,134	$2,381	$2,864	$5,340
Cost		3%	$1,704	$1,704	$1,704	$1,704	$1,704	$1,704
		7%	$1,353	$1,353	$1,353	$1,353	$1,353	$1,353
Net Benefit		3%	$2,270	$2,810	$5,938	$1,534	$1,858	$4,938

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Vehicle, w/ pre-tax	Fuel	$, no-discount	3%	7%
Tractor trucks	757	$2,448	$1,982	$1,574
Single unit trucks	84	$260	$211	$167
Buses	22	$71	$57	$46
total	863	$2,780	$2,250	$1,786

	7%	$1,833	$2,267	$4.781	$1,218	$1,511	$3,987

Table 23. Net benefits for SUTs, with 60 mph speed limiter, in M's, 2013 dollars

SUT			Vehicle-based			Person-based		
Odds Ratio			1.014	1.079	1.053	1.035	1.097	1.068
Benefit	Safety& Property	3%	$37	$164	$121	$88	$193	$150
		7%	$30	$132	$97	$70	$155	$120
	Fuel & GHG	3%	$96	$96	$96	$96	$96	$96
		7%	$75	$75	$75	$75	$75	$75
	Total benefit	3%	$133	$260	$217	$184	$289	$246
		7%	$105	$207	$172	$145	$230	$195
Cost		3%	$210	$210	$210	$210	$210	$210
		7%	$167	$167	$167	$167	$167	$167
Net Benefit		3%	-$77	$50	$7	-$26	$79	$36
		7%	-$62	$40	$5	-$22	$63	$28

Table 24. Net benefits for Buses, with 60 mph speed limiter, in M's, in 2013 dollars

Bus			Vehicle-based			Person-based		
Odds Ratio			0.996	1.081	1.12	1.024	1.165	1.098
Benefit	Safety& Property	3%	$0	$88	$114	$42	$173	$128
		7%	$0	$71	$92	$34	$139	$103
	Fuel & GHG	3%	$25	$25	$25	$25	$25	$25
		7%	$20	$20	$20	$20	$20	$20
	Total benefit	3%	$25	$113	$139	$67	$198	$153
		7%	$20	$91	$112	$54	$159	$123
Cost		3%	$51	$51	$51	$51	$51	$51
		7%	$41	$41	$41	$41	$41	$41
Net Benefit		3%	-$26	$62	$88	$16	$147	$102
		7%	-$21	$50	$71	$13	$118	$82

In summary, the marginal safety benefits decrease as the maximum speed of a speed limiting device decreases from 68 mph to 60 mph. The benefits estimates indicate that substantially more lives would be saved if heavy vehicles are limited to 65 mph versus 68 mph, with a less substantial increase in lives saved if the vehicles were limited to a speed of 60 mph instead of 65 mph. Conversely, the costs associated with additional drivers would increase as the maximum speed decreases for the same travel distance. In addition, we note that a sizeable speed differential could be observed when the speed limiting device is set at 60 mph.

Appendix J Simulation for Fuel Savings Speed Sweep Analysis

To evaluate the effect of a road speed governor on the fuel economy of a tractor trailer truck, a series of vehicle simulation runs was completed using a model of a Kenworth T700 tractor, combined with a 53-foot box van trailer. This vehicle model was extensively evaluated in a program conducted by SwRI to inform NHTSA and EPA's development of Phase 2 Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles. The tractor used for the simulation is shown in Figure 1. The simulations were run over a range from 60 MPH to 80 MPH, in 1 MPH increments. Two types of road were simulated: level ground, and rolling terrain. Simulation of vehicle operation on level ground results in the engine operating at a single speed/load point for a given vehicle speed. The effect of rolling terrain will be described below.

The simulations were intended to address vehicles that would be sold in the model year (MY) 2018 and 2027 time frames. The MY 2018 vehicle complies with last stringency step of the Phase 1 engine and tractor fuel efficiency/GHG requirements. Since Phase 1 did not regulate trailers, the MY 2018 trailer was modeled with tire rolling resistance and aerodynamic features that would allow it to comply with the first step of the trailer standards in NHTSA and EPA's joint Phase 2 Notice of Proposed Rulemaking (NPRM). The MY 2027 vehicle was modeled to comply with the final step of the proposed Phase 2 standards for engine and tractor fuel efficiency/GHG requirements. The 2027 vehicle also was set up to use a 6 X 2 axle configuration and an approximate 25% reduction in accessory power demand. The MY 2027 trailer was modeled to comply with the final step of the proposed Phase 2 trailer standards.

Figure 1. Kenworth T700 Tractor

Each vehicle configuration and speed was run over a range of five payloads:

- 0% payload (empty truck)
- 50% payload
- GEM payload
- 100% payload (80,000 pounds GCW)
- 42,000 pounds payload

For the simulation runs with a grade, the profile provided in the NPRM was used. Because this profile results in an overall elevation reduction of 50 meters over the length of the cycle, the route was modified to include running the route forwards (net downhill elevation change of 50 meters) and then backwards (giving a net uphill change of 50 meters). This was done to create a drive cycle with no net elevation change, except for a slight integration error. Figure 2 shows the grade profile used for this simulation work.

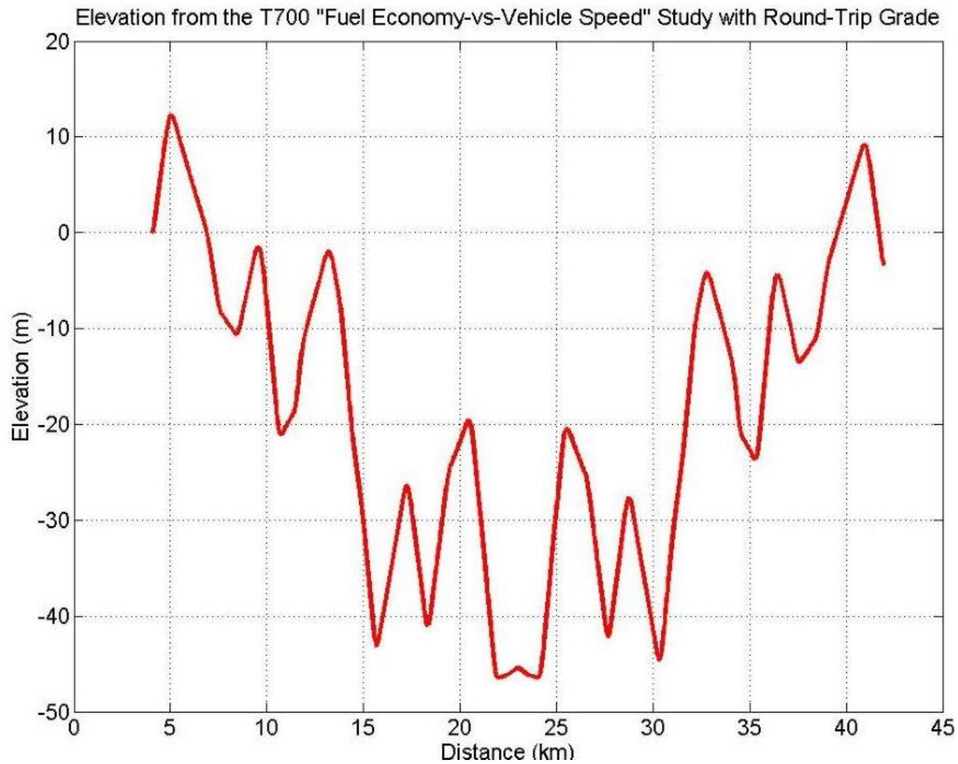

Figure 2. Grade profile of the drive cycle used to simulate the effect of hills.

The level ground results show a nearly linear relationship between road speed and MPG over the range of 60 to 80 MPH. The speed sensitivity is greatest at zero payload, and least at 100% payload. This makes sense, because aerodynamic drag is independent of payload, while rolling resistance (Crr) is directly proportional to payload. Power demand due to rolling resistance increases linearly with speed, while power demand due to aerodynamic drag increases with speed cubed. Thus, if other factors are held constant, a truck with a higher coefficient of drag (Cd) value will have a greater sensitivity of fuel economy to speed.

Figure 3 shows the relationship between cruise speed and fuel economy for the 2018 tractor-trailer on the level ground drive cycles, and Figure 4 provides the same relationships for the drive cycles with grades. In Figure 4, the vehicle with zero payload is able to run the cycles at the target speeds, but as payload increases, speed drops on the uphill segments. Therefore, the results shown in Figure 4 show the actual achieved cycle average speeds, which at full load can be as much as 1.6 MPH less than the target speed.

In comparing Figures 3 and 4, the impact of the cycle with grade is minimal for the zero payload case. The average speeds and the fuel economy are almost identical with and without grades. However, as payload increases, the average speed on the cycles with grade starts to fall, and fuel economy is also reduced, especially at the lower speeds. At 100% payload, the impact of grade reduces fuel economy from 6.87 to 6.53 MPG at 60 MPH target speed, for a 5% reduction in MPG. At 80 MPH target speed, the fuel economy is 4.83 MPG on level ground, and it actually improves to 4.96 MPG with a grade. However, on the cycle with grades, the average speed falls to 78.37 MPH. If the curve fit is extrapolated to a cycle average of 80 MPH, it would get 4.82 MPG. At 80 MPH, there is virtually no difference in fuel economy between the level ground results and the results with grades. Thus, the impact of grade, at least for the vehicle simulated for this study, is to reduce the sensitivity of fuel economy to speed.

Tables 1 and 2 provide the 2nd order polynomial curve fits for the results of the 2018 vehicle without grade (Table 1) and with grade (Table 2). Looking at the range of 65 to 67 MPH, the sensitivity of MPG to speed falls in a range of 2.1% per MPH at zero payload, down to 1.7% per MPH at 100% payload. These results are for the no grade case. With grades, the 2018 vehicle shows a sensitivity of 2.0% per MPH at no load to 1.3% at 100% payload. Note that these values are somewhat larger than those typically found in the literature.

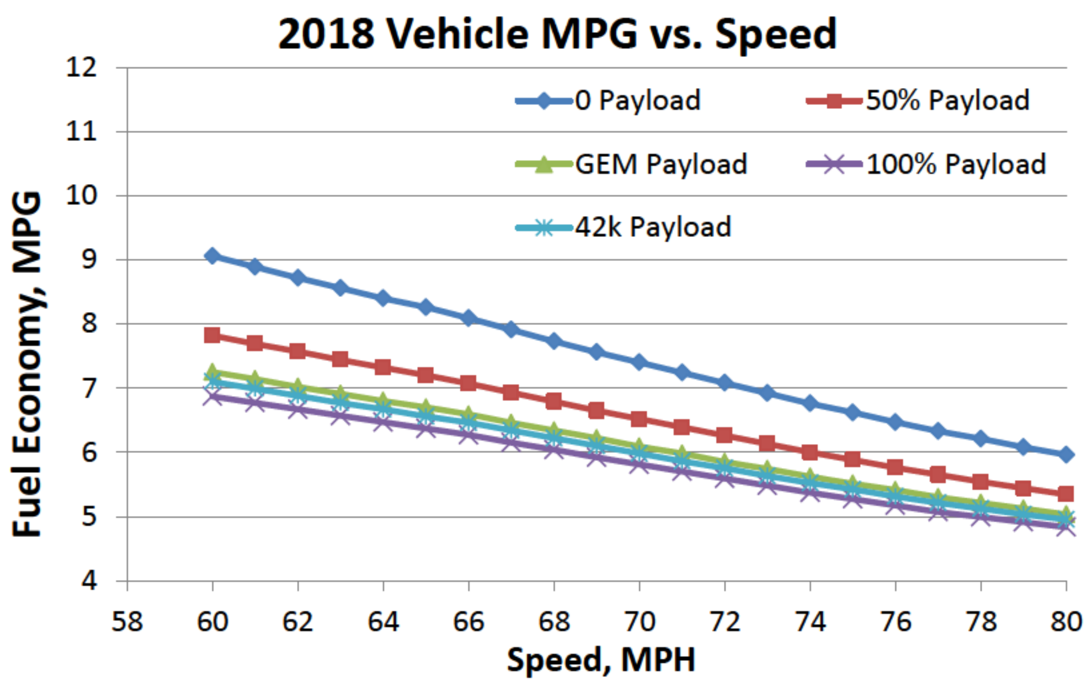

Figure 3. 2018 vehicle fuel economy sensitivity to speed, over a range of payloads, with zero grade.

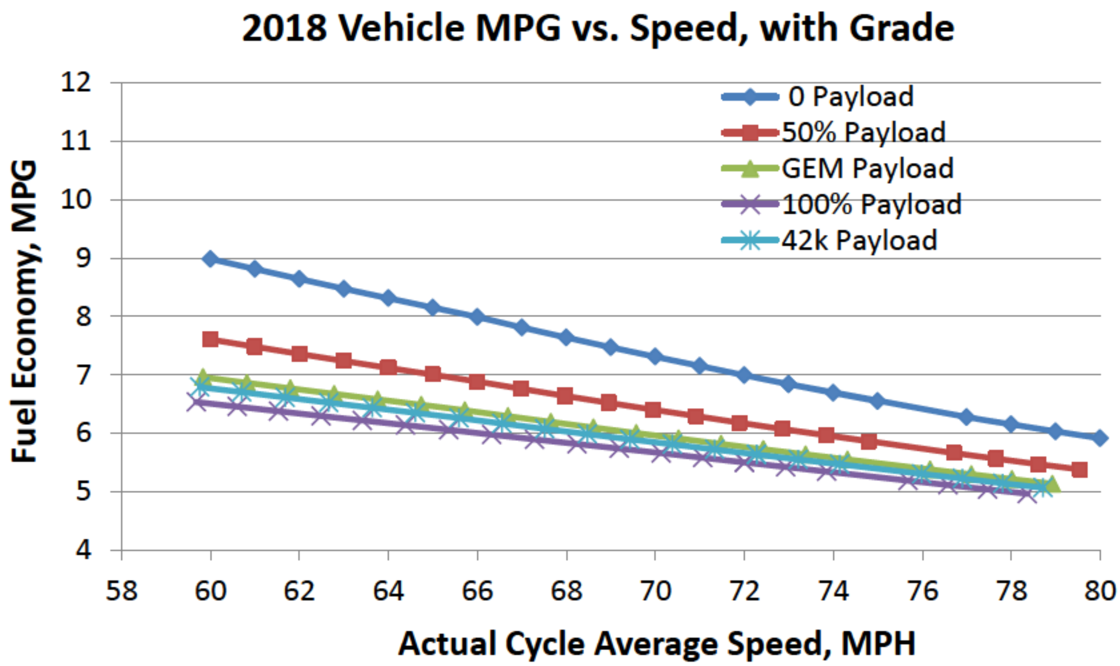

Figure 4. 2018 vehicle fuel economy sensitivity to speed, over a range of payloads, with grades.

Table 1. 2nd Order Polynomial Curve Fits For 2018 Vehicle Level Ground Results (Corresponds to Fig. 3).

Payload	Equation	R^2 Value
0% Payload	MPG = 0.001024 Speed^2 - 0.301325 Speed + 23.479766	0.9995
50% Payload	MPG = 0.000541 Speed^2 - 0.202668 Speed + 18.060496	0.9994
GEM Payload	MPG = 0.000403 Speed^2 - 0.170246 Speed + 16.038356	0.9993
100% Payload	MPG = 0.000348 Speed^2 - 0.154037 Speed + 14.888708	0.9991
42k Payload	MPG = 0.000376 Speed^2 - 0.163133 Speed + 15.556489	0.9992

Table 2. 2nd Order Polynomial Curve Fits For 2018 Vehicle Results With Grades (Corresponds to Fig. 4).

Payload	Equation	R^2 Value
0 Payload	MPG = 0.001347 Speed^2 - 0.344667 Speed + 24.836	0.9997
50% Payload	MPG = 0.000680 Speed^2 - 0.209784 Speed + 17.751	0.9999
GEM Payload	MPG = 0.000262 Speed^2 - 0.132766 Speed + 13.974	0.9999
100% Payload	MPG = -0.000036 Speed^2 - 0.079054 Speed + 11.374	0.9999
42k Payload	MPG = 0.000141 Speed^2 - 0.111070 Speed + 12.925	0.9999

Figures 5 and 6 provide the results for the 2027 vehicle with and without grades, while Tables 3 and 4 provide the matching 2nd order polynomial curve fits. As expected, the 2027 vehicle gets better fuel economy. In comparing Figures 5 and 6, the impact of the cycle with grade is minimal for the zero payload case. The average speeds and the fuel economy are almost identical with and without grades. However, as payload increases, the average speed on the cycles with grade starts to fall, and fuel economy is also reduced, especially at the lower speeds. At 100% payload, the impact of grade reduces fuel economy from 8.37 to 7.76 MPG at 60 MPH target speed, for a 7.3% reduction in MPG. At 80 MPH target speed, the fuel economy is 5.98 MPG on level ground, and 5.94 MPG with a grade. However, on the cycle with grades, the average speed falls to 79.14 MPH.

Note that the drop in average speed on grade for the 2027 vehicle is less than for the 2018 vehicle. This is because the reduced vehicle power demand of the 2027 truck leaves more power available to climb hills. If the curve fit for the 2027 truck at full GCW is extrapolated to a cycle average of 80 MPH, it would get 5.86 MPG, which represents a 1.3% penalty compared to level ground. This is a larger penalty for running on grades than was found with the 2018 vehicle. However, the main impact of grade in the drive cycle, at least for the two vehicles simulated for this study, is to reduce the sensitivity of fuel economy to speed.

Tables 3 and 4 provide the 2nd order polynomial curve fits for the results of the 2027 vehicle without grade (Table 3) and with grade (Table 4). The 2027 vehicle has an almost identical sensitivity to speed changes compared to the 2018 vehicle. Looking at the range of 65 to 67 MPH, the sensitivity of MPG to speed falls in a range of 2.0% per MPH at zero payload, down to 1.7% per MPH at 100% payload. These results are for the no grade case. With grades, the 2027 vehicle shows a sensitivity of 2.0% per MPH at no load to 1.3% at 100% payload. Note that these values are somewhat larger than those typically found in the literature.

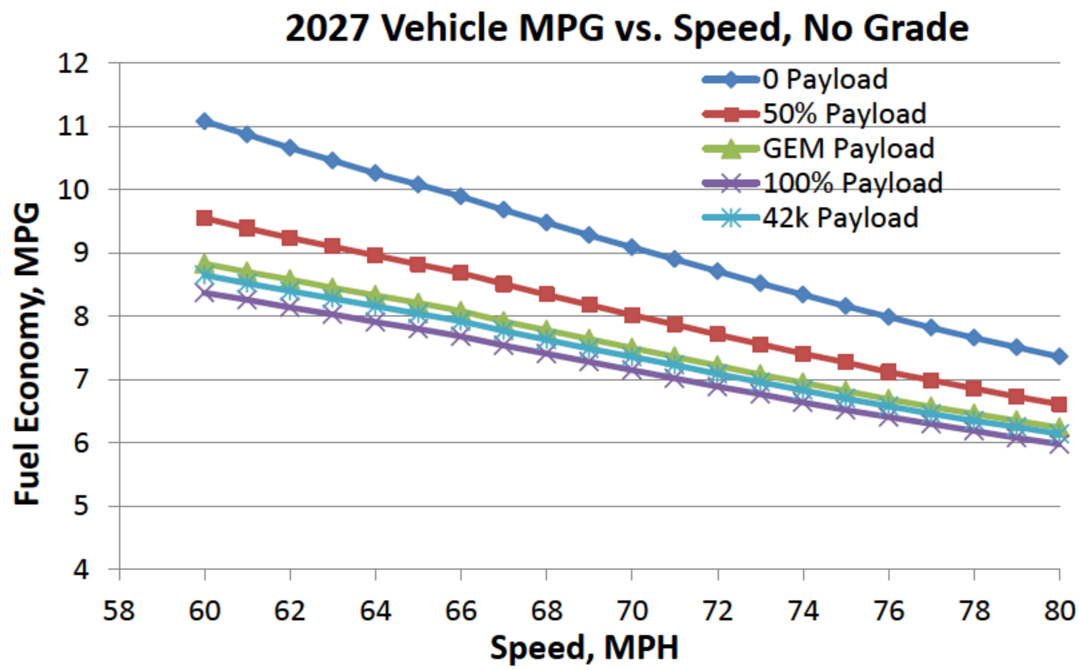

Figure 5. 2027 vehicle fuel economy sensitivity to speed, over a range of payloads, with zero grade.

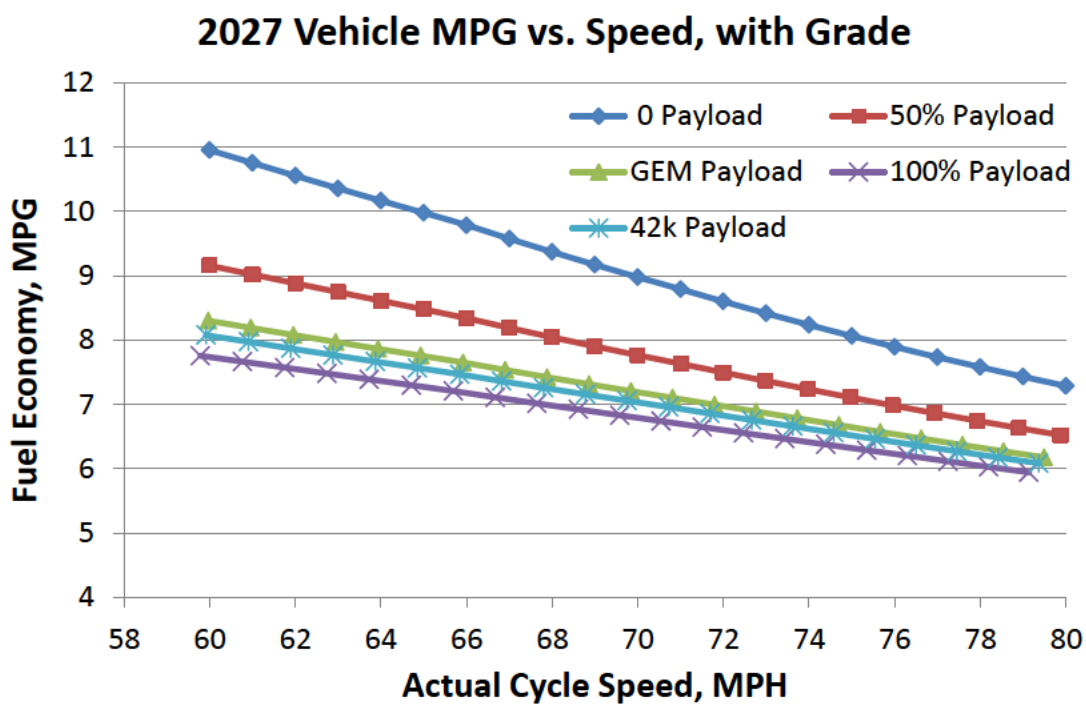

Figure 6. 2027 vehicle fuel economy sensitivity to speed, over a range of payloads, with grades.

Table 3. 2nd Order Polynomial Curve Fits For 2027 Vehicle Level Ground Results.

Payload	Equation	R^2 Value
0% Payload	$MPG = 0.001236\ Speed^2 - 0.361055\ Speed + 23.304017$	0.9998
50% Payload	$MPG = 0.000457\ Speed^2 - 0.213870\ Speed + 20.759801$	0.9994
GEM Payload	$MPG = 0.000312\ Speed^2 - 0.176715\ Speed + 18.340496$	0.9992
100% Payload	$MPG = 0.000232\ Speed^2 - 0.155008\ Speed + 16.868193$	0.9994
42k Payload	$MPG = 0.000293\ Speed^2 - 0.169569\ Speed + 17.795165$	0.9993

Table 4. 2nd Order Polynomial Curve Fits for 2027 Vehicle With Grade.

Payload	Equation	R^2 Value
0 Payload	$MPG = 0.001362\ Speed^2 - 0.377154\ Speed + 28.709$	0.9997
50% Payload	$MPG = 0.000628\ Speed^2 - 0.222195\ Speed + 20.249$	0.9998
GEM Payload	$MPG = 0.000157\ Speed^2 - 0.131343\ Speed + 15.618$	0.9999
100% Payload	$MPG = 0.000073\ Speed^2 - 0.104308\ Speed + 13.739$	0.9999
42k Payload	$MPG = 0.000106\ Speed^2 - 0.117639\ Speed + 14.747$	0.9999

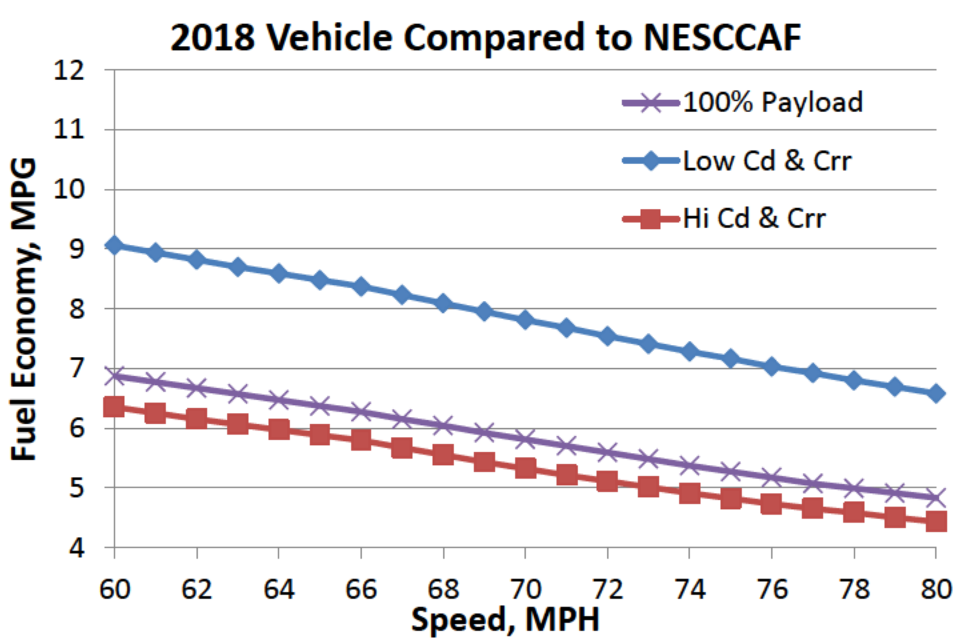

Figure 7. Comparison of fuel economy vs. road speed on level ground for three truck configurations.

Because results for sensitivity of fuel economy to road speed indicated a higher sensitivity than is typical in the literature (around 1% per MPH), some additional work was conducted to explore the issue. The vehicle was evaluated using Cd and Crr values that had been used in previous research. The "low Cd and Crr" version used a Cd of 0.40 and a Crr of 0.0045, while the "hi Cd and Crr" version used a Cd of 0.63 and a Crr of 0.0068. Figure 7 shows results for the 2018 vehicle, along with the low and high Cd and Crr scenarios. The simulations shown in Figure 7 were all made using the level ground drive cycles.

The 2018 baseline vehicle performs better than the high Cd and Crr scenario, by a modest margin of about 0.5 MPG. The low Cd and Crr scenario performs even better than the 2027 truck. The sensitivities of fuel economy to cruise speed for all three scenarios are very similar.

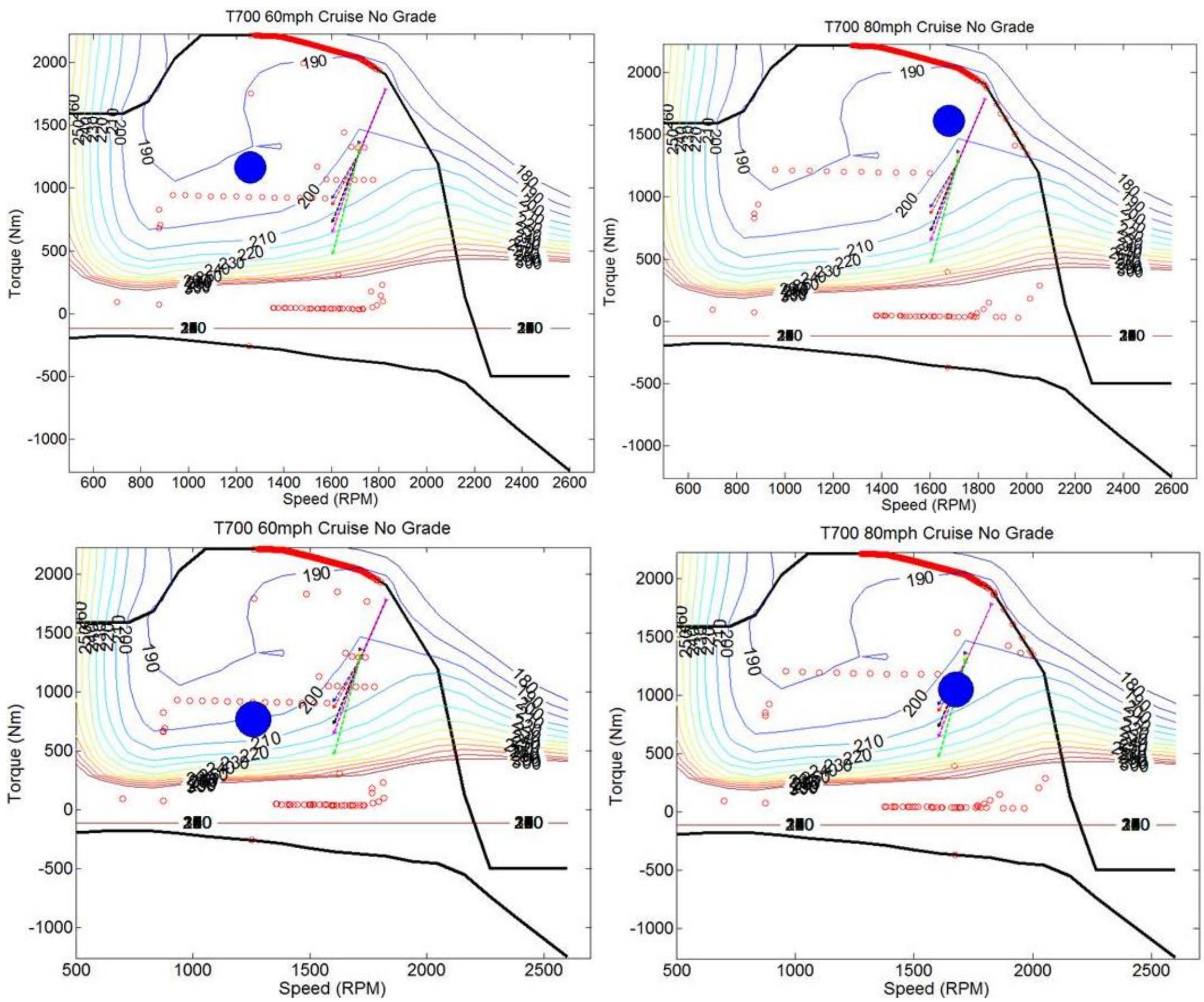

Figure 8. Engine operating points at 60 MPH with high Cd and Crr (top left), 60 MPH with low Cd and Crr (bottom left), 80 MPH with high Cd and Crr (top right), and 80 MPH with low Cd and Crr (bottom right).

Finally, Figure 8 shows how the engine operates at 60 and 80 MPH with low and high Cd and Crr values. The gearing does not change, so engine RPM is proportional to road speed. As speed increases, the engine moves to a slightly less efficient part of the operating map. Comparing the two upper plots, at 80 MPH, the engine is about 3% less efficient than at 60 MPH. BSFC increases from the low 190s (in units of g/kW-hr) at 60 MPH to the high 190s at 80 MPH. This accounts for about a 0.15% fuel economy penalty per MPH. Also note that as the vehicle power demand decreases (by going to lower Cd and Crr values), engine efficiency is also reduced. Therefore, the fuel consumption benefit from a reduction in vehicle power demand is somewhat less than the percent change in power demand. These results will vary from engine to engine, and also can be at least partially compensated for by changing overall vehicle gearing.

Conclusions:

1. For the vehicles evaluated, the sensitivity of MPG to road speed is nearly linear over the range that was considered (60 to 80 MPH).
2. As vehicle payload increases, sensitivity of fuel economy to speed decreases. This is because rolling resistance (which is related to vehicle weight) becomes a larger share of vehicle power demand as payload increases.
3. Introduction of cycles with grade makes little difference in vehicles running empty. As payload increases, grade tends to reduce fuel economy. Note that the grades used are relatively modest, and the hills are short. Little or no downshifting was required.
4. The 2027 vehicle has much better fuel economy than the 2018 vehicle, but a similar sensitivity of fuel economy to speed.
5. Changing road speed drives changes in engine speed. In the case of the engine simulated here, higher road speed pushed the engine into a less efficient part of its operating map.
6. Reducing vehicle power demand (by reducing Cd and Crr) also moved the engine to a less efficient point in its operating map.
7. Results for the new simulations were validated against prior results in literature. The comparisons indicate that the new simulation results fall within the range of expected values.