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

NHTSA

PRELIMINARY REGULATORY IMPACT ANALYSIS

FMVSS No. 228

Pedestrian Head Protection

Office of Regulatory Analysis and Evaluation

NCSA

August 2024

Contents

List of Abbreviations

AASB	Average Annual Safety Benefits
AEB	Automatic Emergency Braking
AIS	Abbreviated Injury Scale
CRSS	Crash Report Sampling System
CY	Calendar Year
DOT	Department of Transportation
ECE	Economic Commission for Europe
ELS	Equivalent Lives Saved
E.O.	Executive Order
EU	European Union
FARS	Fatality Analysis Reporting System
FMVSS	Federal Motor Vehicle Safety Standard
FRIA	Final Regulatory Impact Analysis
GES	General Estimates System
GTR	Global Technical Regulation
GTR 9	Global Technical Regulation No. 9
GVWR	Gross Vehicle Weight Rating
HIC	Head Injury Criterion
KM/H	Kilometers per Hour
LERL	Leading Edge Reference Line
LSB	Lifetime Safety Benefits
LTV	Light Trucks and Vans
MAIS	Maximum Abbreviated Injury Scale
MPG	Miles per Gallon
MPV	Multipurpose Passenger Vehicles
MY	Model Year
NA	North America
NAICS	North American Industry Classification System
NCAP	New Car Assessment Program
NHTSA	National Highway Traffic Safety Administration
NPRM	Notice of Proposed Rulemaking
OMB	Office of Management and Budget
PAEB	Pedestrian Automatic Emergency Braking
PCDS	Pedestrian Crash Data Set
PRIA	Preliminary Regulatory Impact Analysis
QALY	Quality-Adjusted Life-Year
RFA	Regulatory Flexibility Analysis
RFC	Request for Comment
RRL	Rear Reference Line
SRL	Side Reference Line

SUV	Sport Utility Vehicles
U.S.	United States
VMT	Vehicle Miles Traveled
VSL	Value of a Statistical Life
WAD	Wrap Around Distance

Executive Summary

This Preliminary Regulatory Impact Analysis (PRIA) presents the benefits and costs associated with a proposed rule to require vehicles to meet Head Injury Criterion (HIC) reference values when subjected to a headform impact test simulating a pedestrian's head contact with a vehicle's front end. The proposed requirements would apply to newly manufactured vehicles with a gross vehicle weight rating (GVWR) of 4,536 kg (10,000 lbs.) or less.

The impacts of the proposed rule have been examined under Executive Order 12866, Executive Order 13563, Executive Order 14094, the Regulatory Flexibility Act (5 U.S.C. 601-612), the Congressional Review Act/Small Businesses Regulatory Enforcement Fairness Act (5 U.S.C. 801, Pub. L. 104-121), and the Unfunded Mandates Reform Act of 1995 (Pub. L. 104-4). Executive Orders 12866, 13563, and 14094 direct us to assess all benefits, costs, and transfers of available regulatory alternatives and, when regulation is necessary, to select regulatory approaches that maximize net benefits (including potential economic, environmental, public health and safety, and other advantages; distributive impacts; and equity). A regulatory action is significant under Section 3(f)(1) of E.O. 12866, as amended by E.O. 14094, if the action "has an annual effect on the economy of $200 million or more (adjusted every three years by the Administrator of OIRA for changes in gross domestic product); or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or State, local, territorial, or tribal governments or communities." The action's effects include benefits, costs, or transfers. This proposed rule is a significant regulatory action under Section 3(f)(1), as amended by E.O. 14094.

The National Highway Traffic Safety Administration's (NHTSA) proposal would specify a new Federal Motor Vehicle Safety Standard (FMVSS) No. 228, "Pedestrian head protection," that would limit the accelerations measured by headforms. The proposed rule would require light vehicles to meet an injury assessment criterion called the Head Injury Criterion (HIC) when subjected to a headform impact test simulating a pedestrian's head contact with a vehicle's front end. The purpose of the standard would be to reduce, to the extent possible, the risk of serious or fatal head injury to pedestrians caused when a light vehicle strikes a pedestrian.

The proposed standard specifies that the HIC must be less than 1000 ($HIC_{15}1000$)[1] over two-thirds of the Hood Area, confined within the Test Area, as these terms are defined by the proposal. Furthermore, the proposed standard specifies that remaining Test Area is limited to HIC1700. Lastly, there is no specified HIC requirement for any remaining area on the Hood Top that is not within the Test Area. It is expected that vehicle manufacturers will meet the requirements specified in the proposed standard by incorporating pedestrian protection design enhancements into the front end of vehicles.

The Notice of Proposed Rulemaking (NPRM) initiates the process of adopting Global Technical Regulation No. 9 (GTR 9), "Pedestrian safety," into the Federal safety standards. In 1998, the United States (U.S.) signed the "Agreement Concerning the Establishing of Global Technical Regulations for Wheeled Vehicles, Equipment and Parts which can be Fitted and/or be Used on Wheeled Vehicles," commonly referred to as the "1998 Agreement."[2] The 1998 Agreement provides for the establishment of global technical regulations (GTR) regarding the safety, emissions, energy conservation, and theft prevention of wheeled vehicles, equipment, and parts.

---

[1] $HIC_{15} = \left\{\left[\frac{1}{t_2-t_1}\int_{t_1}^{t_2} a(t)dt\right]^{2.5}\right\}_{max}, where\ t_2 - t_1 \leq 15\ milliseconds$

[2] The 1998 Agreement is administered by the UN Economic Commission for Europe's World Forum for the Harmonization of Vehicle Regulations (WP.29).

Under the 1998 Agreement, Contracting Parties voting in favor of establishing a GTR are obligated to submit the regulation to the process used in the country to adopt the requirement into the agency's law or regulation.[3] As NHTSA voted in favor of establishing GTR 9, the NPRM initiates rulemaking per the processes of the 1998 Agreement.

One of NHTSA's highest safety priorities is improving pedestrian safety. Although in 2009 the US reached a low of pedestrian deaths, the number of pedestrian fatalities has increased in nearly each following year.[4] NHTSA is issuing the NPRM because it has tentatively decided the proposed standard would meet the requirements for FMVSS established by the National Traffic and Motor Vehicle Safety Act. In specifying the requirements limiting the accelerations measured by headforms, the agency aims to ensure that light vehicles are designed to mitigate the risk of serious and fatal head injuries to both adults and children in pedestrian crashes.

Table 1 presents the safety issue which is comprised of the fatalities and non-fatal injuries to pedestrians that could potentially be addressed by the proposed rule. Between 2016 and 2020, an annual average of 6,232 fatalities and 72,707 non-fatal injury cases were incurred by pedestrians in front end crashes involving light vehicles.[5]

Table 1: Safety Issue addressed by the Proposed Rule

Category	**Pedestrians with Non-Fatal Injuries (2016-2020 Annual Average)**						**Fatalities**
	MAIS 1	**MAIS 2**	**MAIS 3**	**MAIS 4**	**MAIS 5**	**MAIS 1-5**	
Passenger Cars	28,126	7,646	4,014	388	240	40,414	3,080
Light Trucks and Vans (LTV)	22,763	6,018	3,053	287	172	32,293	3,152
Total	50,889	13,664	7,067	675	412	72,707	6,232

Note: Values may not sum due to rounding. Injuries and fatalities were rounded to the nearest whole number for presentation purposes.

[3] For more information about the GTR, please see Section IV of the NPRM preamble.
[4] https://www.nhtsa.gov/book/countermeasures-that-work/pedestrian-safety
[5] Fatality data are from 2019.

Several adjustments were made to the target population to reflect those fatalities and non-fatal injuries potentially addressed by the proposed rule. Adjustments to the target population include accounting for benefits associated with Pedestrian Automatic Emergency Braking (PAEB), as well as adjusting the target population to reflect those fatalities and non-fatal injuries in which at least one of the most severe injuries was a head injury, in which the impacts were to the Test Area, and at impact speeds at which effectiveness can be calculated.

This analysis makes use of the data from testing conducted by the agency that was conducted at head-to-vehicle impact speeds up to 40 km/h. When establishing the target population potentially addressed by the proposed rule, this analysis makes use the available data to reflect cases in which Head Impact Speed would be less than 40 km/h. The initial target population provides data on posted speed limits but not vehicle impact speeds. This analysis addresses that limitation by adjusting the target population based on the estimated relationship between posted speed limit and vehicle impact speed. Therefore, this analysis is able to establish those injuries and fatalities in the target population that correspond to the vehicle impact speeds reflected in the test data. As test data limitations prevent effectiveness estimates at impact speeds greater than approximately 46 km/h, the target population is adjusted to reflect fatalities and non-fatal injuries occurring at impact speeds up to 46 km/h.

In order to relate the fatalities and non-fatal injuries reflected in the real world crash data to the test data, this analysis uses the GTR 9 assumption that Head Impact Speed (real-world head-to-vehicle impact speed) can be estimated as 0.875 of Vehicle Impact Speed (vehicle-to-pedestrian's body impact speed). Therefore, after adjusting the target population to reflect those injuries and fatalities by vehicle impact speed, this analysis makes use of the test data to calculate effectiveness at Vehicle Impact Speeds approximately 46 km/h (40 km/h/0.875= 45.7

km/h) and below.

To estimate the incremental benefits and costs associated with the proposed rule, this analysis first establishes the probability of fatality and non-fatal injury resulting from a head injury in tests with the current fleet as a baseline. Therefore, the incremental benefits associated with the proposed rule result from the change in the probability of fatality and non-fatal injury resulting from an impact with a vehicle meeting the proposed standard relative to the baseline (impacts with vehicles not meeting the proposed standard).

Table 2 presents a summary of the annual incremental benefits associated with the proposed rule. Under the proposed rule, approximately 67.4 fatalities would be mitigated annually. As the benefits associated with the proposed rule are the result of the decrease in probability of fatalities and non-fatal injuries, those fatalities mitigated become less severe injuries as a result of the proposed rule. That is, the proposed rule results in a decrease in the number of fatalities but results in an increase in number of less severe non-fatal injuries as those mitigated fatalities trickle-down into non-fatal injuries and more severe injuries trickle-down to less severe injuries. As a result of the trickle-down, the decrease in fatalities is approximately equal to the increase in non-fatal injuries.

Table 2: Summary of Annual Incremental Benefits

Injury Severity	**Benefits by Vehicle Type**		**Total Benefits**
	Passenger Cars	**LTVs**	
MAIS 1	-23.3	-47.2	-70.5
MAIS 2	-3.7	1.2	-2.5
MAIS 3	7.0	16.8	23.9
MAIS 4	-0.7	-0.3	-1.1
MAIS 5	-2.5	-2.6	-5.1
Fatalities	27.8	39.7	67.4

Note: Values may not sum due to rounding. Negative values represent an increase in the number of injuries at that specific severity.

The proposed effective date of the rule is the first September 1, two years after publication of the final rule. Thus, the agency is proposing a minimum lead time of two years after the date of the publication of the final rule. Additionally, multistage manufacturers and alterers would be allowed an additional year of lead time.

Many manufacturers of vehicles that would be subject to the proposed rule also manufacture vehicles in the European Union (EU) market. Potentially, some of these vehicles under production could be designed to a regulatory body's application of GTR 9 that may differ from a NHTSA rule implementing GTR 9 in the U.S. Therefore, for such vehicles, there could be a potential one-time cost associated with redesigning vehicle hoods to comply with the requirements specified in the proposed rule. NHTSA has limited data available to estimate the size of these costs associated with redesigning vehicle hoods. The agency believes, however, that these one-time costs should be relatively minimal, as other countries currently already have similar requirements to what NHTSA is proposing. NHTSA requests comment on this assumption (described in Section 5.3, "Unquantified Costs"). When comparing the same or similar models of vehicles with and without the countermeasures that would be used to meet the proposed rule, the assemblies had no perceived differences in design or assembly but did indicate a slight difference in weight. Therefore, this analysis estimates the impact that the incremental weight associated with meeting the requirements specified in the proposed rule may have on fuel economy for passenger cars and LTVs, respectively.

Table 3 presents the total annual cost associated with the proposed rule. When discounted at three and seven percent, the incremental cost associated with the impact to fuel economy is estimated at approximately $60.4 million and $48.9 million, respectively.

Table 3: Total Annual Cost

Category	Number of Vehicles Impacted	Per Vehicle Cost		Total Fuel Economy Cost	
		Discounted at 3%	Discounted at 7%	Discounted at 3%	Discounted at 7%
Passenger Car	6,257,000	$3.50	$2.86	$21,923,153	$17,887,026
LTV	9,445,000	$4.08	$3.29	$38,507,293	$31,055,176
Total Annual Cost				**$60,430,447**	**$48,942,202**

Note: Values may not sum due to rounding.

Cost-effectiveness and benefit-cost analyses enable decision-makers to compare regulatory alternatives. Benefits which are measured in fatalities and non-fatal injuries mitigated are reflected in equivalent lives saved (ELS) for the cost-effectiveness analysis and translated into monetary value for the benefit-cost analysis. As both the benefits and costs associated with this proposed rule are realized over the course of a vehicle's lifespan, both are discounted to represent their present value.

Table 4 summarizes the findings of the cost-effectiveness and benefit cost analyses. When discounted at three and seven percent, the cost per equivalent life saved is approximately $1.10 million. As the cost per equivalent life saved is less than the comprehensive economic cost of a fatality, which is estimated at approximately $11.9 million in 2020 dollars,[6] the proposed rule is considered to be cost-effective. When discounted at three and seven percent, net benefits associated with the proposed rule are approximately $593.3 million and $480.8 million, respectively. Positive net benefits indicate that the proposed rule is net beneficial.

Table 4: Summary of Costs and Benefits

Discount Rate	Cost (Millions)	Equivalent Lives Saved	Cost per Equivalent Life Saved (Millions)	Monetized Benefits (Millions)	Net Benefits (Millions)
3%	$60.43	54.87	$1.10	$653.76	$593.33
7%	$48.94	44.46	$1.10	$529.74	$480.79

[6] The Economic and Societal Impact of Motor Vehicle Crashes, 2019, DOT HS 813 403, February 2023. https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813403

As the conclusions drawn from this analysis may be impacted by the underlying assumptions, this PRIA includes sensitivity and uncertainty analyses. The sensitivity analysis considers how the findings of the cost-effectiveness and benefit cost analyses may be impacted based on those assumptions. The sensitivity analyses included in this PRIA examine alternative values for the value of statistical life (VSL), the adjustment made to the target population to account for head injuries as MAIS, and the composition of the fleet when estimating fuel economy costs. Furthermore, the uncertainty analysis analyzed the potential impact that important uncertainties may have on the results of the conclusions of this analysis. When accounting for uncertainty within a Monte Carlo simulation with 10,000 outcomes, the cost-effectiveness and net benefits measures were very similar to the main analysis. Overall, the sensitivity and uncertainty analyses support the findings in the main analysis indicating that the proposed rule is cost-effective and net beneficial.

Table 5 provides a summary of the regulatory alternatives that the agency considered for this rulemaking. These regulatory options included a less stringent alternative that matches the interpretation of GTR 9 implemented in various countries represented by an Economic Commission for Europe (ECE) proposal to amend GTR 9[7] regarding test area (this will be called the EU interpretation of GTR 9) and a more stringent alternative that specifies the requirements for the entire Hood Top instead of just the Test Area. Although the more stringent alternative offers higher benefits than the proposed rule, this analysis takes into account uncertainty about feasibility and costs associated with the regulatory alternative.

[7] TWSG-01-04 - ECE-TRANS-WP29-2021-053e, https://unece.org/sites/default/files/2021-02/ECE-TRANS-WP29-2021-053e.pdf

Table 5: Summary of Regulatory Alternatives (Millions)

Regulatory Alternatives	Relative to Preferred Option	Considerations
#1: Requirements are the same as the EU interpretation of GTR 9 regarding test area (GTR 9 Amendment 3)	Less Stringent Alternative	Lower benefits and similar costs result in higher cost per ESL and smaller net benefit.
#2: Proposed Rule	Preferred Option	Cost-effective and net beneficial.
#3: Requirements apply to the entire Hood Top (No HIC Unlimited Area)	More Stringent Alternative	Higher benefits, but uncertainty about feasibility and costs due to larger hood reconfiguration.

Lastly, we acknowledge that this analysis faces several limitations in regard to how the world will look in the future. That is, the analysis makes use of the available data to best characterize the assumptions made in the analysis such as the safety problem potentially addressed by the proposed rule and trends in vehicle sales. Although we acknowledge that these factors reflected in the analysis will change over time, any future projection of each of these factors introduce greater uncertainty into the analysis. Furthermore, inconsistency or inaccuracy in these projections may distort the comparison of benefits and costs.

1. Introduction

This Preliminary Regulatory Impact Analysis (PRIA) accompanies the National Highway Traffic Safety Administration's (NHTSA) Notice of Proposed Rulemaking (NPRM) to establish Federal Motor Vehicle Safety Standard (FMVSS) No. 228, "Pedestrian head protection." The proposed rule is based on Global Technical Regulation No. 9 (GTR 9), "Pedestrian Safety." The proposed rule would require light vehicles to meet an injury assessment criterion called the Head Injury Criterion (HIC) when subjected to a headform impact test simulating a pedestrian's head contact with a vehicle's front end.

Vehicles subject to the proposed rule are new light vehicles, which consist of passenger cars, trucks (which includes pickups), multipurpose passenger vehicles (MPV) (MPVs include sport utility vehicles (SUV), crossover vehicles, and some vans), and buses with a GVWR of 10,000 lbs. (4,536 kg) or less. NHTSA's field data sources typically segment light vehicles into two groups: passenger cars and light trucks and vans (LTVs). LTVs capture essentially all light vehicles other than passenger cars with a GVWR of 10,000 lbs. or less, which include pickups, SUVs, and vans. Large pickups and SUVs are more common in the United States (U.S.) than in other parts of the world.

One of NHTSA's highest safety priorities is improving pedestrian safety. In specifying the requirements limiting the accelerations measured by headforms, the agency aims to ensure that light vehicles are designed to mitigate the risk of serious and fatal head injuries to both adults and children in pedestrian crashes. The requirements specified in the proposed rule are based on the HIC as computed from the acceleration of the headforms upon impact. The HIC must not exceed 1000 over two-thirds of the hood surface defined as the Hood Area, confined within the headform Test Area (see Chapter 2 for a description of these areas). The HIC for the remaining Test Area must not exceed 1700. The HIC requirements, referred to respectively as HIC1000 and

HIC1700 herein, apply to both the child and adult headforms. Furthermore, the agency recently requested comment on the proposal to update NHTSA's New Car Assessment Program (NCAP) to provide consumers with information about crashworthiness pedestrian protection of new vehicles. As an informational campaign, NCAP aims to provide valuable safety information to consumers about the ability of vehicles to protect pedestrians and could incentivize vehicle manufacturers to produce vehicles that provide better protection for vulnerable road users such as pedestrians.[8] For a more detailed description of the requirements specified in the proposed rule and NHTSA's request for comment (RFC) on NCAP, please see the NPRM.

As detailed in the NPRM, there are important differences between the NCAP RFC and Standard No. 228. The fact that there will be a pedestrian crashworthiness component of NCAP does not mean that there should not be a standard related to the same safety risk. For example, the introduction of the frontal and side crashworthiness portions of NCAP did not lead the agency to abandon standards in these areas.

NCAP remains a consumer information program that provides consumers vehicle safety information for their purchasing decisions. Providing this information encourages manufacturers to voluntarily make changes to vehicles that reflect positively in the NCAP safety information and thereby improves safety through the marketplace. FMVSSs, on the other hand, are mandatory and mandate at least a minimum level of safety that all new vehicles *must* provide to *every* purchaser. NHTSA has observed that, in the case of both electronic stability control and rear visibility cameras, only approximately 70 percent of vehicles had these technologies during the time they were part of NCAP. Thus, while NCAP serves a vital safety purpose, NHTSA also recognizes its limitations in ensuring that every vehicle provides the performance necessary to

[8] 87 FR 27200, Docket NHTSA-2023-0020

provide the requisite level of safety to all purchasers. Because only an FMVSS can ensure that all vehicles are equipped with technologies and vehicle designs that meet the specified performance requirements, NCAP can supplement but not substitute for the FMVSS. The FMVSS remain NHTSA's core way of ensuring that all motor vehicles provide the requisite level of safety performance, and provide it within a practicable timeframe. Although the NCAP program provides valuable safety-related information to consumers in a simple and easy-to-understand manner, the agency believes that the proposed rule is necessary to achieve the highest level of pedestrian safety feasible and at the fastest achievable timeframe based on the performance requirements and lead time specified in the proposed rule.

HIC is a well-established measure of the likelihood of head injury arising from an impact and has been used in numerous FMVSSs. It has been established that a HIC value of 1000 (HIC1000) represents an 11 percent risk of a brain injury classified as a severe injury, including fatal injuries, which is denoted as MAIS 4+F on the Maximum Abbreviated Injury Scale (MAIS). Furthermore, a HIC value of 1700 (HIC1700) represents a 36 percent risk (Eppinger, Kleinberger, Kuppa, Saul, & Sun, 1999) of MAIS 4+F injury.

This PRIA estimates the incremental benefits and costs associated with the proposed rule relative to the baseline. Incremental benefits and costs represent the difference in benefits and costs of the proposed rule relative to the baseline, which represents the status quo in absence of the proposed rule. Unless otherwise specified, all costs are presented in 2020 dollars.

In specifying the baseline, this analysis establishes the average probability of fatalities and non-fatal injuries resulting from head injuries given the current countermeasures included in light vehicles. This analysis then calculates the probability of fatalities and non-fatal injuries when light vehicles meet the requirements specified in the proposed rule. Incremental benefits are then calculated by reflecting the difference in those respective probabilities on the fatalities and non-fatal injuries reflected in the target population.

The Office of Management and Budget's (OMB) A-4 Circular defines the term "distributional effect" as the impact of a regulatory action across the population and economy, divided up in various ways. In assessing the potential distributional effects, NHTSA considered the populations that would realize the benefits associated with the proposed rule. Benefits associated with the proposed rule are the result of mitigating the severity of injuries to pedestrians who are struck by light vehicles. Overall, the proposed rule will generate safety benefits for pedestrians across the board. These safety benefits are not specific to urban or rural populations, specific age groups, or income groups. Therefore, we do not anticipate any distributional effects from the proposed rule.

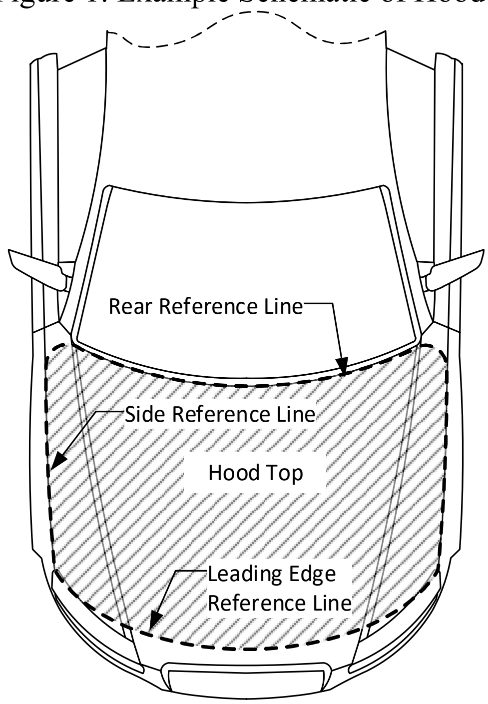
The rest of this document is organized as follows: Chapter 2 presents the hood geometry and terminology used in this analysis, Chapter 3 presents the target population, Chapter 4 presents the benefits associated with the proposed rule, Chapter 5 presents the costs associated with the proposed rule, Chapter 6 presents the lead time specified in the proposed rule, Chapter 7 presents the cost-effectiveness and benefit-cost analyses conducted for the proposed rule, Chapter 8 presents the sensitivity and probabilistic uncertainty analyses, Chapter 9 presents the regulatory alternatives considered by the agency, and Chapter 10 presents the Regulatory Flexibility Act and Unfunded Mandates Reform Act.

2. Hood Geometry and Terminology

This chapter presents the hood geometry and terminology used in this analysis. Figure 1 displays the base area of the hood, which is known as the Hood Top. The Hood Top is enclosed by the intersection of the following borders (these borders are depicted in the figure below):

- Front border: Leading Edge Reference Line.
- Side border: Side Reference Lines.
- Rear border: Rear Reference Line.

Figure 1: Example Schematic of Hood Top



Note: For illustration purposes only.

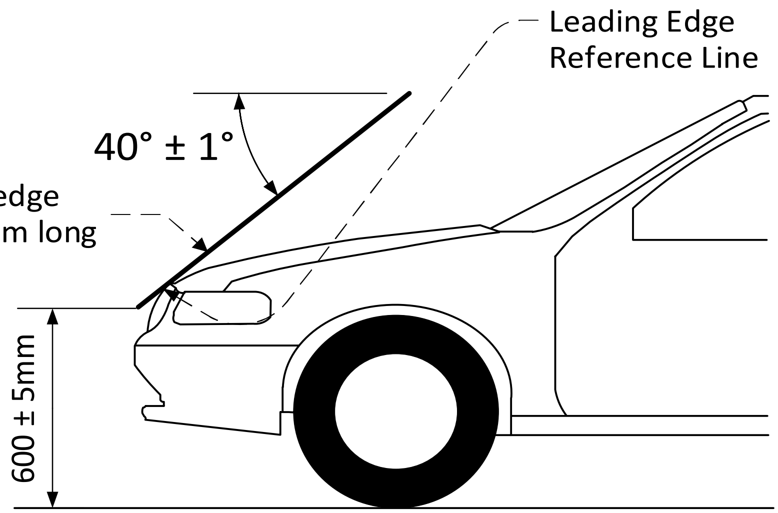
The following subsections discuss the each of the three borders in detail.

2.1. Front Border of the Hood Top

The front border of the Hood Top consists of the vehicle's "Leading Edge Reference Line" (LERL). The LERL is determined for most vehicles by running a 1,000 mm straight edge angled at 40° (down from the horizontal) along the front edge of the vehicle. The lower end of the straight edge is specified to be 600 mm off the ground. The specified height of 600 mm was chosen to avoid the bumper when marking off the hood leading edge.

Figure 2 illustrates the LERL. The length and angle of the straight edge result in the upper end being placed at 1,243 mm from ground level. The use of 40° angle provides an objective means to delineate the grill/bumper from the hood. Moving along the width of the front-end and while holding the straight edge parallel to the vehicle x-z plane, the contact points between the straight edge and the vehicle define the line. The reference to a 1,000 mm long straight edge is in the GTR 9.

Figure 2: Leading Edge Reference Line



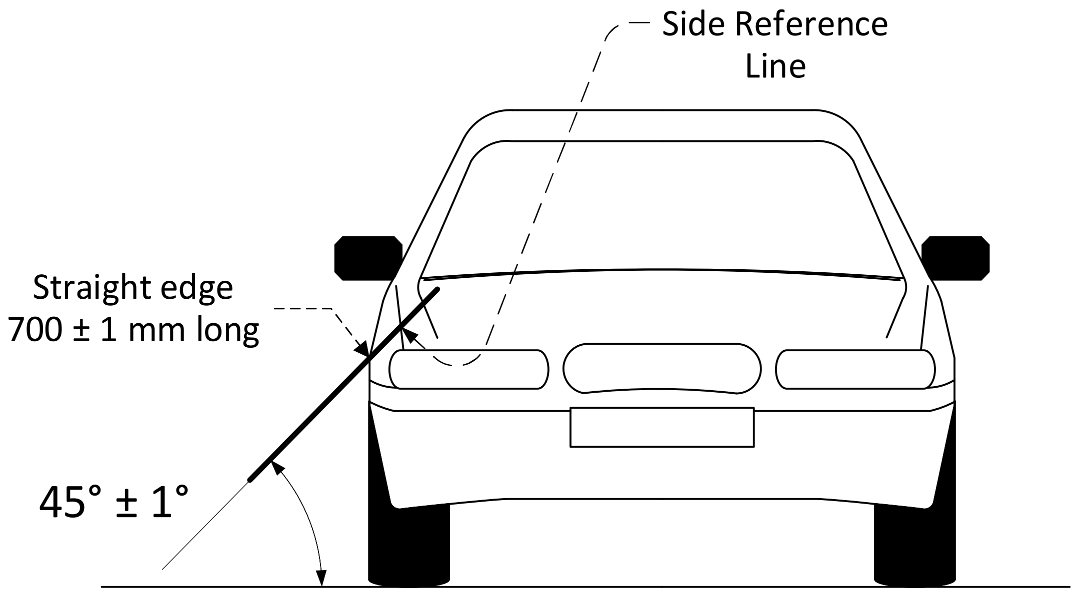
Note: For illustration purposes only.

2.2. Top Side Border of the Hood Top

The side borders of the Hood Top would be determined by identifying the Side Reference Lines (SRL).

Figure 3 illustrates the SRL. A SRL would be drawn by running a straight edge angled at 45° along the side of the vehicle. Unlike in the procedure establishing the LERL, the straight edge is not held at a fixed distance from the ground when determining the SRL. The 45° angle provides and objective means to delineate the fender from the hood. Moving along the length of the vehicle, the contact points between the straight edge and the vehicle define the SRL.

Figure 3: Defining the Side Reference Line

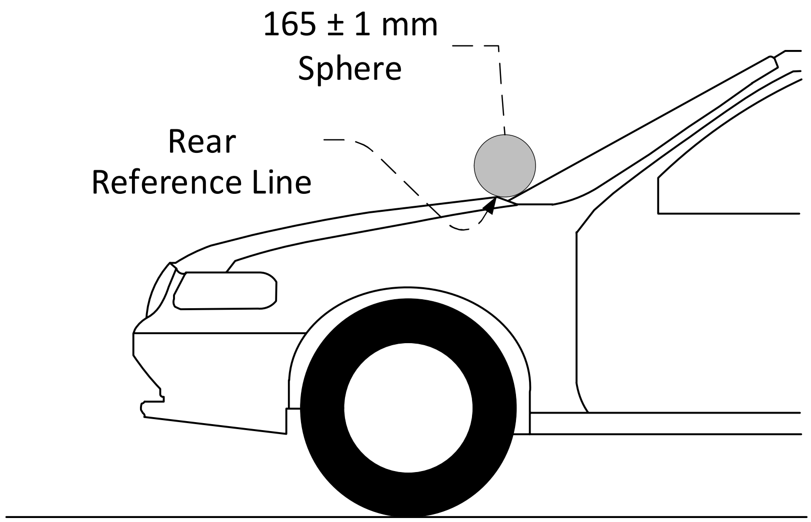


Note: For illustration purposes only.

2.3. Rear Border of the Hood Top

The rear border of the Hood Top would be determined by identifying the Rear Reference Line (RRL). Figure 4 illustrates the RRL. The RRL would be determined by inserting a 165 mm sphere into the cowl and against the windshield such that the sphere is in contact with the windshield and a point on the surface of the hood (usually its rear edge). The RRL is formed by moving the sphere along the width of the windshield while always keeping the sphere in contact with the windshield and the hood. The contact points between the sphere and the hood define the RRL.

Figure 4: Rear Reference Line



2.4. Hood Area

After identifying the Hood Top, the next step is to establish the Hood Area.[9] The Hood Area (see light grey area in Figure 5) is enclosed by the intersection of the following borders:

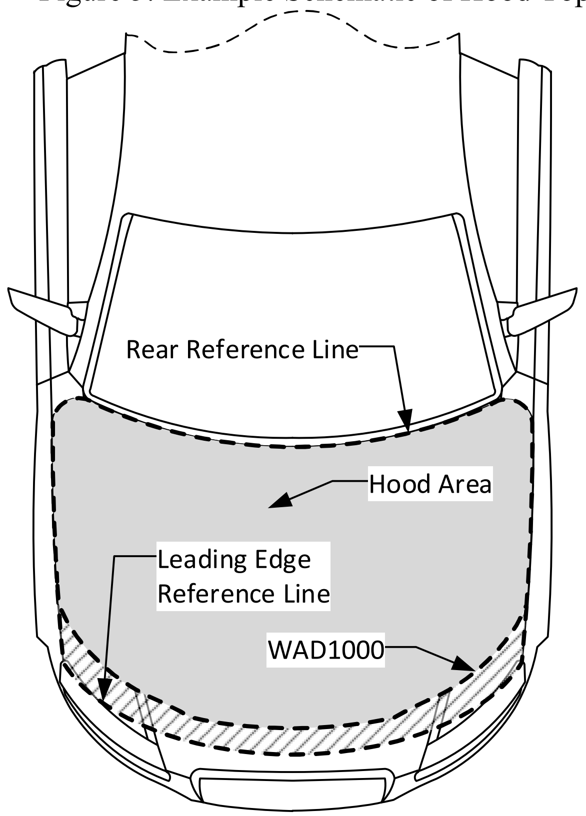
- Front border: Leading Edge Reference Line (LERL) or the wrap around distance (WAD) of 1000 mm (WAD1000) line, whichever is most rearward at the point of measurement.
- Side border: Side Reference Lines (SRL).
- Rear border: Rear Reference Line (RRL), or the WAD2100 line, whichever is most forward at the point of measurement.

The region defined as the Hood Area can be identical to the Hood Top but may be smaller. It can be reduced in size from the Hood Top if WAD1000 or WAD2100 lines are on the Hood Top. The Hood Area cannot be forward of WAD1000 and cannot be rearward of

[9] For some vehicles, the Hood Area may be equivalent to the Hood Top. Also, we note that GTR 9 does not define a Hood Area. In GTR 9, the equivalent area would be what GTR 9 refers to the “combined child and adult headform test areas.” We have defined Hood Area for increased clarity.

WAD2100. It can contain areas on the top-facing portion of the fender and the cowl.

Figure 5: Example Schematic of Hood Top



Note: For illustration purposes only.

Contained within the Hood Area are the Child and Adult Headform Test Areas. For convenience, we will refer to these combined areas as the Test Area. The Test Area is smaller than the Hood Area to account for specified regions that are not subject to HIC limits under the GTR, which we call “HIC Unlimited Area.” The HIC Unlimited Area shares an outer boundary with the Hood Top. Its inner boundary is called the HIC Unlimited Margin. The HIC Unlimited Margin forms the outer boundary of the Child and Adult Headform Test Areas. The Test Area is arrived at by subtracting an 82.5 mm margin inward from the boundary of the Hood Area.

The Child Headform Test Area (See Figure 6) is enclosed by the intersection of the following borders:

- Front border: HIC Unlimited Margin of the Leading Edge Reference Line.[10]
- Side borders: HIC Unlimited Margins of the Side Reference Lines.
- Rear border: WAD1700 line or the HIC Unlimited Margin of the Rear Reference Line, whichever is most forward at the point of measurement.

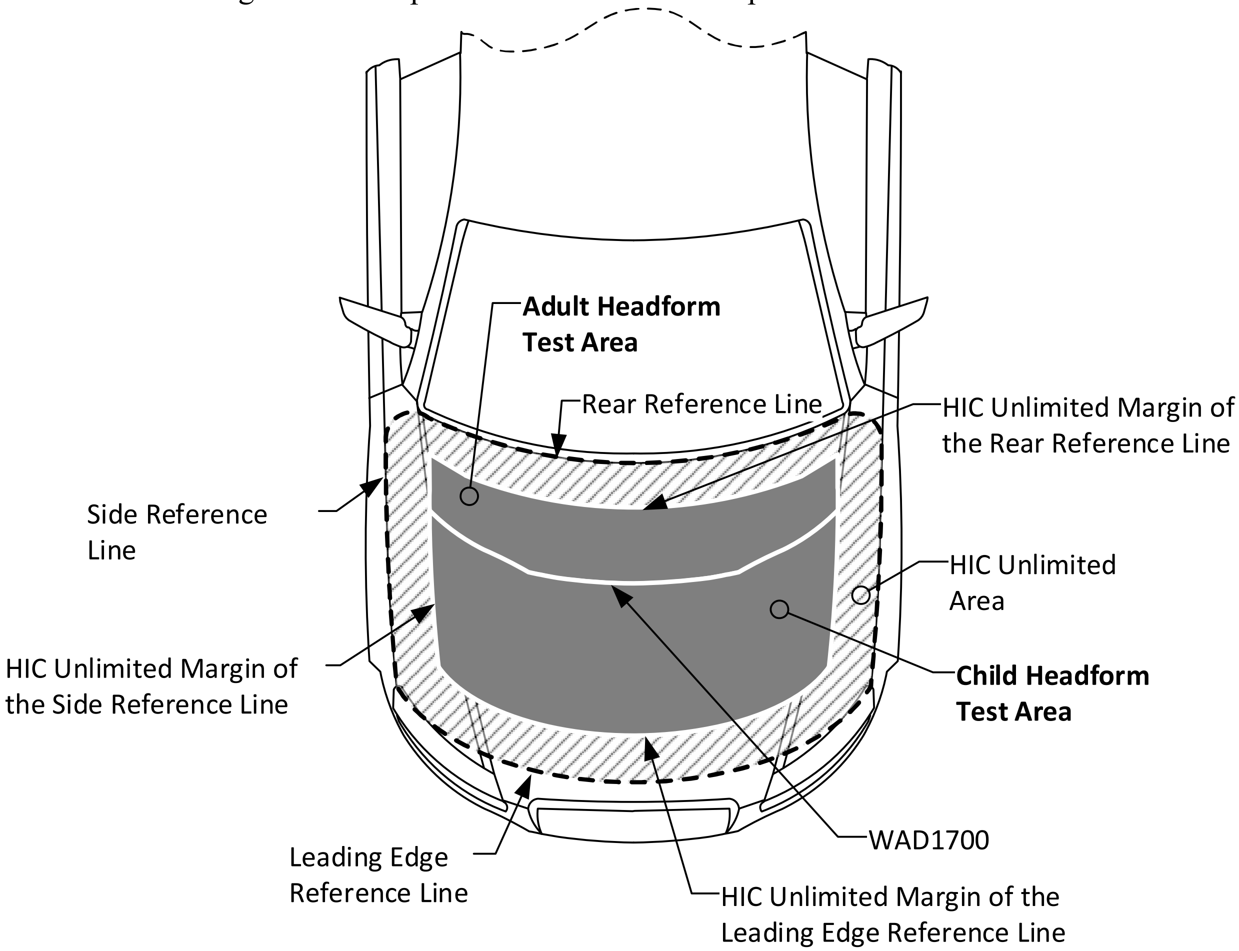
The Adult Headform Test Area (See Figure 6) is enclosed by the intersection of the following borders:

- Front border: WAD1700 line.
- Side borders: HIC Unlimited Margins of the Side Reference Lines.
- Rear border: HIC Unlimited Margin of the Rear Reference Line.[11]

Figure 6 shows the final Test Area in dark grey.

[10] This is either the 82.5 mm offset line or the WAD1000 line, whichever is more rearward.
[11] This either the 82.5 mm offset line or the WAD2100 line, whichever is more forward.

Figure 6: Example Schematic of Hood Top with Final Test Area



Note: For illustration purposes only.

3. Target Population

This chapter presents the target population potentially addressed by the proposed rule. The next section in this chapter presents the initial target population. The following sections then present the adjustments made to that initial target population. Adjustments to the target population include accounting for benefits associated with Pedestrian Automatic Emergency Braking (PAEB). After accounting for the benefits for PAEB, this analysis then adjusts the target population to reflect those fatalities and non-fatal injuries in which one of the most severe injuries was a head injury, in which the impacts were to the Test Area, and at vehicle-pedestrian impact speeds less than or equal to 46 km/h.

3.1. Initial Target Population

The fatalities presented in the initial target population reflect the annual average fatalities based on 2019 Fatality Analysis Reporting System (FARS) data. The non-fatal injuries presented in the initial target population reflect the annual average number of pedestrians who incurred non-fatal injuries based on 2016-2020 data from the Crash Report Sampling System (CRSS).[12] Note this analysis uses the term non-fatal injuries to refer to the number of pedestrians who incurred non-fatal injuries. Furthermore, the target population is disaggregated by passenger car and LTV body types.

MAIS represents the maximum injury severity of an occupant at an Abbreviated Injury Scale (AIS) level. AIS is an anatomically based injury severity scoring system that classifies injury on a 6-level severity scale. NHTSA maintains nationally representative crash databases that are primarily based on police-reported crash records in which injuries are categorized only by KABCO ratings. These crash databases include the FARS, the General Estimates System (GES), and CRSS.

The derivation of the initial target population involves querying the databases to filter for crashes that could potentially be addressed by the requirements specified in the proposed rule. The CRSS crash database does not provide detailed information about injury severity based on the MAIS coding scheme. Instead, the CRSS records injury severity on the KABCO scale from police crash reports.

Table 6 presents the annual average of pedestrians injured in front end crashes by KABCO severity between 2016 and 2020. KABCO stands for Fatality (K), Incapacitating Injury (A), Non-Incapacitating Injury (B), Possible Injury (C), and Property Damage Only (O). Note that the

---

[12] 2020 provides the most recent available data, but 2019 data were chosen to eliminate any potential effects of the COVID-19 pandemic on target population.

fatality data (K) is from FARS while the rest of the data is weighted data from CRSS.

Table 6: Annual Average of Pedestrians in Front End Crashes by KABCO Severity and Vehicle Type in 2016-2020 CRSS and FARS Cases

Vehicle Type	No Apparent Injury (O)	Possible Injury (C)	Non-Incapacitating Injury (B)	Incapacitating Injury (A)	Killed (K)	Injury Severity Unknown (U)	Total KABCO Injuries
Passenger Car	671	14,119	19,263	8,038	3,080	835	46,005
LTV	415	10,960	16,434	5,718	3,152	665	37,345

This analysis accounts for non-fatal injuries which are designated by injury severity by MAIS. MAIS is based on an ordinal scale of one to six presented in Table 7. KABCO is crash assigned which means that it is determined by non-medical personnel. On the other hand, MAIS is assigned based on review of medical records.

Table 7: MAIS Categories

MAIS	Severity
0	Not Injured
1	Minor Injury
2	Moderate Injury
3	Serious Injury
4	Severe Injury
5	Critical Injury
6	Maximum (untreatable) Injury

Table 8 presents the KABCO to MAIS conversion matrix for non-occupants. KABCO-to-MAIS translators are tools NHTSA uses to convert KABCO injuries to their MAIS equivalent injuries. The KABCO-to-MAIS translators allow injury data from more than one dataset to be compared and combined for injury research under a standardized injury rating. The 2022 revision of the KABCO-to-MAIS translators reflect the most current real-world crash environments.[13]

[13] Wang, J.S. (2023). KABCO-to-MAIS translators - 2022 update (Report No. DOT HS 813 420). National Highway Traffic Safety Administration.

As the calculation of benefits requires injuries to be reported on the MAIS scale, KABCO injuries must be translated to MAIS injuries. Therefore, to present the target population on the MAIS scale, this analysis applies the values in the conversion matrix to the KABCO injuries presented in Table 6 for passenger cars and LTVs, respectively.

Table 8: KABCO to MAIS Translation Factors for Non-Occupants)[14] (Wang, 2023)

Injury Severity	O	C	B	A	K	U, Injured
	No Injury	**Possible Injury**	**Non-Incapacitated**	**Incapacitated**	**Killed**	**Unknown Severity**
MAIS 0[15]	0.7370	0.1057	0.0221	0.0060	0.0000	0.0254
MAIS 1	0.2358	0.7397	0.7456	0.3196	0.0000	0.6788
MAIS 2	0.0220	0.1185	0.1685	0.3144	0.0000	0.2167
MAIS 3	0.0048	0.0319	0.0598	0.2861	0.0000	0.0572
MAIS 4	0.0004	0.0032	0.0027	0.0348	0.0000	0.0029
MAIS 5	0.0000	0.0010	0.0005	0.0259	0.0000	0.0026
Fatal	0.0000	0.0000	0.0008	0.0132	1.0000	0.0165
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Note: AIS 2005 version/updated 2008.

Table 9 presents the annual converted fatalities and non-fatal injuries in the preliminary target population for passenger car-pedestrian front-end crashes disaggregated by non-fatal MAIS 0-5 and fatal.

[14] These translators are appropriate for non-occupants, pedestrians, motorcyclists, and cyclists.

[15] In this table, MAIS 0-5 correspond to non-fatal cases at each MAIS severity level

Table 9: Annual Fatalities and Non-fatal Injuries in Passenger Cars

Injury Severity	O	C	B	A	K	U, Injured	Preliminary Target Population
	No Injury	Possible Injury	Non-Incapacitated	Incapacitated	Killed	Unknown Severity	
MAIS 0	494	1,492	426	49	0	49	2,511
MAIS 1	158	10,444	14,374	2,603	0	547	28,126
MAIS 2	15	1,673	3,248	2,561	0	149	7,646
MAIS 3	3	450	1,153	2,330	0	78	4,015
MAIS 4	0	45	52	283	0	8	389
MAIS 5	0	14	10	211	0	5	239
Fatal	0	0	0	0	3,080	0	3,080
Total	671	14,119	19,263	8,038	3,080	835	46,005

Note: Values may not sum due to rounding.

Table 10 presents the annual converted fatalities and non-fatal injuries in the preliminary target population for LTV-pedestrian front-end crashes disaggregated by non-fatal MAIS 0-5 and fatal.

Table 10: Annual Fatalities and Non-fatal Injuries in LTVs

Injury Severity	O	C	B	A	K	U, Injured	Preliminary Target Population
	No Injury	Possible Injury	Non-Incapacitated	Incapacitated	Killed	Unknown Severity	
MAIS 0	306	1,159	363	35	0	37	1,900
MAIS 1	98	8,107	12,263	1,852	0	443	22,763
MAIS 2	9	1,299	2,771	1,822	0	117	6,018
MAIS 3	2	350	984	1,658	0	59	3,052
MAIS 4	0	35	44	202	0	6	287
MAIS 5	0	11	8	150	0	3	173
Fatal	0	0	0	0	3,152	0	3,152
Total	415	10,960	16,434	5,718	3,152	665	37,345

Note: Values may not sum due to rounding.

Table 11 and Table 12 present the initial target population by speed limit for passenger cars and LTVs, respectively. As the methods to calculate benefits in this analysis take into account speed, the target population is presented by speed limit at the location of the crash. We note that adjustments are made for vehicle impact speed later in this chapter. Lastly, due to data limitations, speed limit and real-world pedestrian crash data are used to estimate the distribution of vehicle impact speed.

Table 11: Initial Target Population for Passenger Cars

Injury Severity	Speed Limit (mph/km/h)				
	<25 mph <40 km/h	30 mph 48 km/h	35 mph 56 km/h	40+ mph 64+ km/h	TOTAL
MAIS 1	9,788	3,620	7,000	7,718	28,126
MAIS 2	2,463	907	1,965	2,311	7,646
MAIS 3	1,185	437	1,070	1,323	4,015
MAIS 4	108	40	106	134	389
MAIS 5	63	23	67	87	239
Total MAIS 1-5	13,607	5,027	10,208	11,573	40,415
Fatalities	266	253	571	1,991	3,080

Note: Fatalities and non-fatal injuries are rounded to the nearest whole number for presentation purposes.

Table 12: Initial Target Population for LTVs

Injury Severity	Speed Limit (mph/km/h)				
	<25 mph <40 km/h	30 mph 48 km/h	35 mph 56 km/h	40+ mph 64+ km/h	TOTAL
MAIS 1	8,345	2,651	5,801	5,965	22,763
MAIS 2	2,025	686	1,557	1,750	6,018
MAIS 3	929	338	805	981	3,052
MAIS 4	81	31	77	98	287
MAIS 5	45	18	47	62	173
Total MAIS 1-5	11,425	3,724	8,287	8,856	32,293
Fatalities	342	274	573	1,964	3,152

Note: Fatalities and non-fatal injuries are rounded to the nearest whole number for presentation purposes.

3.2. Pedestrian AEB Adjustment

This section presents the adjustment made to the target population to account for benefits for safety impacts of newly required safety technologies that have yet to be applied to the fleet. As those safety technologies would result in fewer crashes and resulting non-fatal injuries and fatalities, the target population considered in this analysis is adjusted in order to be representative of the crash problem potentially addressed by the proposed rule. More specifically, the target population was adjusted to account for the benefits of associated with FMVSS No. 127; "Light vehicle automatic emergency braking (AEB)." The final rule for Light Vehicle AEB includes a pedestrian AEB (PAEB) component. We also note that it is possible that there may be additional fatalities and non-fatal injuries that would fall into the target population potentially addressed by this proposed rule in cases that PAEB results in crash mitigation rather than avoidance. However, due to data limitations we are unable to estimate the number of additional fatalities and non-fatal injuries that may be potentially addressed by this proposed rule following PAEB intervention. Table 13 and Table 14 present the target population after adjusting for PAEB benefits for passenger cars and LTVs, respectively. PAEB is projected to mitigate 2,672 injuries and 238 fatalities (NHTSA, 2023) annually. PAEB injuries and fatalities are deducted proportionately from the target population by injury severity and speed. For example, since 13.46[16] percent of non-fatal pedestrian injuries were MAIS 1 injuries from passenger car crashes that occurred at posted speed limit 40 km/h or less, 13.46 percent of the 2,672[17] PAEB prevented injuries were deducted from the target population of non-fatal MAIS 1 injuries from passenger car crashes that occurred at posted speed limit 40 km/h or less. Similarly, 4.26 percent of pedestrian fatalities were from passenger car crashes that occurred at posted speed limit 40 km/h or less, so 4.26 percent of the 238 PAEB prevented fatalities, or 10.1 fatalities, were deducted from the target population of pedestrian fatalities from passenger car crashes that occurred at posted speed limit 40 km/h or less. As noted earlier, although crashes that were not prevented but were slowed to a pedestrian-vehicle impact speed of 46 km/h or less by PAEB would add to the applicable target population, we assume that all PAEB prevented crashes are deducted from the target population.

[16] $9{,}788.2 \div 72{,}707.4 = 0.1346$

[17] $0.1346 * 2{,}672 = 359.7$

Table 13: PAEB Adjusted Target Population for Passenger Cars

Injury Severity	**Speed Limit (mph/km/h)**				**TOTAL**
	<25	**30**	**35**	**40+**	
	<40	**48**	**56**	**64+**	
MAIS 1	9,428	3,487	6,743	7,434	27,092
MAIS 2	2,372	874	1,892	2,227	7,365
MAIS 3	1,142	421	1,030	1,274	3,867
MAIS 4	104	39	102	129	374
MAIS 5	60	22	65	83	231
Fatalities	255	243	549	1,915	2,962

Note: Fatalities and non-fatal injuries are rounded to the nearest whole number for presentation purposes.

Table 14: PAEB Adjusted Target Population for LTVs

Injury Severity	**Speed Limit (mph/km/h)**				**TOTAL**
	<25	**30**	**35**	**40+**	
	<40	**48**	**56**	**64+**	
MAIS 1	8,039	2,554	5,588	5,746	21,926
MAIS 2	1,951	661	1,500	1,685	5,797
MAIS 3	895	325	775	945	2,940
MAIS 4	78	30	74	94	276
MAIS 5	44	17	45	60	166
Fatalities	329	263	551	1,889	3,032

Note: Fatalities and non-fatal injuries are rounded to the nearest whole number for presentation purposes.

3.3. Head Injuries as MAIS Adjustment

This section presents the adjustment to the PAEB adjusted target population to account for cases in which head injuries were the MAIS (at least one of the maximum AIS injuries to the pedestrian was a head injury from a head-to-hood impact). Cases from the Pedestrian Crash Data Set (PCDS), which used data from 1994 to 1998 (NHTSA, Pedestrian Crash Data Study, 1996 Data Collection, Coding, and Editing Manual, 1996), were analyzed to estimate what proportion of pedestrian fatalities and injuries are associated with head injuries from impacts to vehicle structures subject to the test procedures in the proposed rule. Although PCDS case data did not provide sufficient vehicle front end dimensions to identify whether specific head impacts were in the proposed FMVSS No. 228 Test Area, head injuries from impacts to structures in the Hood Top area (the hood and the fender top) could be identified. Lastly, given the limited data on head injuries as MAIS, we request comment on these assumptions.

Table 15 presents the percentage of head-hood cases by vehicle type for each level of injury severity: these were cases where a head injury with severity equal to the case MAIS resulted from impact to a structure in the Hood Top area. In 15.9 percent of fatal passenger car to pedestrian crashes, pedestrian head injuries attributed to an impact with a structure in the Hood Top area were coded as the most serious or tied for most serious injury in the case (i.e., Head Injury AIS = Case MAIS). In 4.2 percent of MAIS 1 or minor injury pedestrian cases and 6.3 percent of MAIS 2 to MAIS 5 pedestrian cases, a head injury of severity equal to the case MAIS was attributed to an impact to the Hood Top area of the passenger car. Similarly, in 14.8 percent of fatal LTV to pedestrian crashes, pedestrian head injuries attributed to an impact with a structure in the Hood Top area were coded as the most serious or tied for most serious injury in the case. In 2.8 percent of those MAIS 1 pedestrian injury cases and 8.6 percent of MAIS 2 to MAIS 5 pedestrian injury cases, a head injury of severity equal to the case MAIS was attributed to an impact to the Hood Top area of the LTV.

Table 15: Percentage of Pedestrian Head-Hood Cases by Vehicle Type

Injury Severity	**Passenger Cars**	**LTVs**
MAIS 1	4.2%	2.8%
MAIS 2-MAIS 5	6.3%	8.6%
Fatal	15.9%	14.8%

Table 16 and Table 17 present the target population by speed limit after adjusting for cases in which the severity of one or more head injuries from Hood Top impact was equal to the case MAIS for pedestrians impacted by passenger cars and LTVs, respectively. This adjustment reflects the percentages of injuries in Table 15 for passenger cars and LTVs on the PAEB adjusted target population presented in Table 13 and Table 14 above.

Table 16: Head Injury as MAIS Adjusted Target Population for Passenger Cars

Injury Severity	Speed Limit (mph/km/h)				TOTAL
	<25	30	35	40+	
	<40	48	56	64+	
MAIS 1	396	146	283	312	1,138
MAIS 2	149	55	119	140	464
MAIS 3	72	27	65	80	244
MAIS 4	7	2	6	8	24
MAIS 5	4	1	4	5	15
Fatalities	41	39	87	304	471

Note: Fatalities and non-fatal injuries are rounded to the nearest whole number for presentation purposes.

Table 17: Head Injury as MAIS Adjusted Target Population for LTVs

Injury Severity	Speed Limit (mph/km/h)				TOTAL
	<25	30	35	40+	
	<40	48	56	64+	
MAIS 1	225	72	156	161	614
MAIS 2	168	57	129	145	499
MAIS 3	77	28	67	81	253
MAIS 4	7	3	6	8	24
MAIS 5	4	2	4	5	14
Fatalities	49	39	82	280	449

Note: Fatalities and non-fatal injuries are rounded to the nearest whole number for presentation purposes.

3.4. Test Area Adjustment

This section presents the adjustment to the head injury adjusted target population to account for cases in which the most serious injury is a head injury associated with impact to the Test Area. Table 18 and Table 19 present the Test Area adjusted target population for passenger cars and LTV, respectively. As the target population field data include injuries and fatalities caused by head impacts with the Hood Top and the Test Area is smaller than the Hood Top, this section takes into account the ratio of the Test Area to Hood Top is 0.631 and 0.748 for passenger cars and LTVs. Area calculations are average ratios for 16 NHTSA-tested passenger cars and 24 LTVs.[18] The Test Area adjusted target population reflects the respective ratio of the Test Area to Hood Top on the head injury as MAIS adjusted target population presented in Table 16 and

[18] Calculations are provided in Appendix E: Test Area-Hood Top Ratios.

Table 17 above. As there is a lack of data in regard to the distribution of head-hood impact location, this analysis assumes uniform impacts. We request for comment on this assumption.

Table 18: Test Area Adjusted Target Population for Passenger Cars

Injury Severity	Speed Limit (mph/km/h)				TOTAL
	<25	30	35	40+	
	<40	48	56	64+	
MAIS 1	250	92	179	197	718
MAIS 2	94	35	75	89	293
MAIS 3	45	17	41	51	154
MAIS 4	4	2	4	5	15
MAIS 5	2	1	3	3	9
Fatalities	26	24	55	192	297

Note: Fatalities and non-fatal injuries are rounded to the nearest whole number for presentation purposes.

Table 19: Test Area Adjusted Target Population for LTVs

Injury Severity	Speed Limit (mph/km/h)				TOTAL
	<25	30	35	40+	
	<40	48	56	64+	
MAIS 1	168	53	117	120	459
MAIS 2	125	42	97	108	373
MAIS 3	58	21	50	61	189
MAIS 4	5	2	5	6	18
MAIS 5	3	1	3	4	11
Fatalities	36	29	61	209	336

Note: Fatalities and non-fatal injuries are rounded to the nearest whole number for presentation purposes.

3.5. Impact Speed Adjustment

This section presents the adjustment to the test area adjusted target population to account for head impact speed relative to speed limit. There are four relevant speeds in this analysis:

- Head impact speed (real-world head-to-vehicle impact speed)
- Test impact speed (headform-to-vehicle impact speed)
- Vehicle impact speed (vehicle-to-pedestrian's body impact speed)
- Speed limit (posted speed limit).

This analysis makes use of data from testing conducted by the agency at test impact speeds up to 40 km/h. In doing so this analysis must relate the fatalities and non-fatal injuries reflected in the real-world crash data to the test data. This analysis combines the data from the testing conducted by the agency at 32, 35, and 40 km/h. As the majority of the testing was conducted at 40 km/h, we note that there was not enough data at 32 and 35 km/h to consider those speeds separately. Previous work has estimated average head impact speed as 0.875 of vehicle impact speed (GTR 9) Therefore, test data used to calculate effectiveness at test impact speeds of 40 km/h pertain to vehicle impact speeds of approximately 46 km/h (40 km/h/0.875= 45.7 km/h) and below in this analysis.

This analysis makes use of the PCDS to establish the percentage of fatalities and non-fatal injuries by speed limit occurring at vehicle impact speeds of 46 km/h or lower. The initial target population from CRSS and FARS reflects the injuries and fatalities in which the posted speed limit was 40, 48, 56, and 64+ km/h. The PCDS provides estimates of percentage of injuries and fatalities occurring at vehicle impact speeds based on the posted speed limit. Therefore, those percentages can be used to adjust the target population to reflect those occurring at vehicle impact speeds that correspond to those reflected in the test data. Given the limited data on the relationship between posted speed limit and vehicle impact speeds, we request comment on these assumptions.

Table 20 presents the percentage of fatalities and non-fatal injuries with impact speeds less than or equal to 46 km/h by speed limit in PCDS cases. For passenger cars and LTVs, 100 percent of fatalities and non-fatal injuries at speed limits 40 km/h (25 mph) or lower occurred at vehicle impact speeds less than or equal to 46 km/h. For a speed limit of 48 km/h (30 mph), approximately 99 percent of MAIS 1 injuries, 92 percent of MAIS 2 injuries, 88 percent of MAIS 3 injuries, and 59 percent of MAIS 4 injuries, MAIS 5 injuries, and fatalities occurred at vehicle impact speed less than or equal to 46 km/h. For a speed limit of 56 km/h (35 mph), approximately 96 percent of MAIS 1 injuries, 88 percent of MAIS 2 injuries, 82 percent of

MAIS 3 injuries, and 35 percent of MAIS 4 injuries, MAIS 5 injuries, and fatalities occurred at vehicle impact speeds less than 46 km/h. For speed limits 64 km/h (40 mph) or greater, 100 percent of MAIS 1 injuries, approximately 63 percent of MAIS 2 injuries, 57 percent of MAIS 3 injuries, and eight percent of MAIS 4 injuries, MAIS 5 injuries, and fatalities occurred at vehicle impact speeds less than 46 km/h.

Table 20: Percentage of PCDS Cases with Estimated Impact Speed ≤46 km/h

Injury Severity	**Speed Limit (mph/km/h)**			
	<25	**30**	**35**	**40+**
	<40	**48**	**56**	**64+**
MAIS 1	1.0000	0.9917	0.9583	1.0000
MAIS 2	1.0000	0.9245	0.8750	0.6250
MAIS 3	1.0000	0.8788	0.8235	0.5714
MAIS 4 MAIS 5 Fatalities	1.0000	0.5946	0.3529	0.0811

Table 21 and Table 22 present the impact speed adjusted target population for passenger cars and LTVs, respectively. The impact speed adjusted target population applies the adjustment factors presented in Table 20 by injury severity and speed limit (to adjust for the percentage of cases expected to have impact speed under 46 km/h) to the test area adjusted target population presented in Table 18 and Table 19 above.

Table 21: Impact Speed Adjusted Target Population for Passenger Cars

Injury Severity	**Speed Limit (mph/km/h)**				
	<25	**30**	**35**	**40+**	**TOTAL**
	<40	**48**	**56**	**64+**	
MAIS 1	250	92	171	197	710
MAIS 2	94	32	66	55	248
MAIS 3	45	15	34	29	123
MAIS 4	4	1	1	0	7
MAIS 5	2	1	1	0	4
Fatalities	26	14	19	16	75

Note: Fatalities and non-fatal injuries are rounded to the nearest whole number for presentation purposes.

Table 22: Impact Speed Adjusted Target Population for LTVs

Injury Severity	Speed Limit (mph/km/h)				TOTAL
	<25	30	35	40+	
	<40	48	56	64+	
MAIS 1	168	53	112	120	454
MAIS 2	125	39	84	68	317
MAIS 3	58	18	41	35	152
MAIS 4	5	1	2	0	8
MAIS 5	3	1	1	0	5
Fatalities	36	17	22	17	92

Note: Fatalities and non-fatal injuries are rounded to the nearest whole number for presentation purposes.

3.6. Summary

This chapter presented the target population potentially addressed by the proposed rule. Table 23 summarizes the target population used to calculate benefits in the following chapter. Following the approach to the benefits estimation, the target population is presented by vehicle type.

Table 23: Summary of Target Population

Injury Severity	Passenger Cars	LTVs	Total
MAIS 1	710	454	1,164
MAIS 2	248	317	565
MAIS 3	123	152	275
MAIS 4	7	8	15
MAIS 5	4	5	9
Fatalities	75	92	167

Note: Fatalities and non-fatal injuries are rounded to the nearest whole number for presentation purposes.

4. Benefits

This chapter presents the incremental benefits associated with the proposed rule. Benefits associated with the proposed rule are the result of the decrease in the probability of fatality or injury resulting from meeting the requirements specified in the proposed rule. As a result of that decrease in the probability of fatality or injury, for example, fatalities resulting from head injuries in cases that a light vehicle strikes a pedestrian are mitigated and become less severe injuries.

In order to estimate the benefits associated with the proposed rule, this analysis first considers MAIS+F injuries. MAIS+F injuries include all injuries at that severity and greater. For example, MAIS 1+F is the sum of all injuries at an MAIS1 and greater including fatalities. This analysis then estimates the percentage change in probability of fatality or injury resulting from meeting the requirements specified in the proposed rule relative to the baseline to establish the MAIS+F injuries and fatalities we expect to see under the proposed rule. This analysis then separately translates MAIS+F to MAIS injuries and fatalities in both the baseline and proposed rule cases. Lastly, the incremental benefits associated with the proposed rule are calculated as the difference in MAIS injuries and fatalities under the baseline and proposed rule.

This chapter estimates benefits associated with the proposed rule based on testing conducted by the agency to establish the baseline performance of the fleet. Tests were conducted with headform impact speeds of 32, 35, and 40 km/h. The relative majority of tests (46.9 percent) were conducted at headform impact speeds of 40 km/h. Although this proposal applies to headform impacts speeds of 35 km/h, we find no significant difference in effectiveness when disaggregating data by impact speed.[19] Furthermore, we note that the vehicles included in the testing conducted by the agency varied in age. Although there may be potential changes in the fleet over time, this analysis makes use of the available data to characterize the baseline. We request comment on this assumption.

Table 24 presents the values for injury probability as a function of HIC. Hertz (1993) estimated head injury risk as a function of HIC using test data with only short duration impacts. These risk curves were assumed to be valid for HICs of all durations. Eppinger (1999) explains that the Hertz curves "would be applicable to both HIC_{15} and HIC_{36}". However, it is likely that they are especially relevant for shorter duration head impacts (less than 15 ms). These HIC_{15} injury-risk

[19] This analysis also estimated effectiveness with test data that was disaggregated by impact speed and found no significant difference in the overall conclusions of this analysis.

curves are used in this analysis.[20] In estimating effectiveness, the percentage change in fatality and injury probability is estimated based on the HIC injury criterion in baseline testing of the fleet and the improvement expected with the countermeasures used to meet the requirements specified in the proposed rule.

Table 24: Probability of Head Injury by AIS level as function of HIC_{15}

HIC	Prob. of AIS 1+	Prob. of AIS 2+	Prob. of AIS 3+	Prob. of AIS 4+	Prob. of AIS 5+	Prob. of AIS 6 (Untreatable)	Prob. of No Injury
200	47.7%	2.5%	0.2%	0.0%	0.0%	0.0%	52.3%
400	73.5%	12.5%	2.4%	0.3%	0.2%	0.1%	26.5%
600	84.9%	25.2%	7.7%	1.9%	1.3%	0.8%	15.1%
800	90.6%	37.1%	15.0%	5.5%	4.3%	2.9%	9.4%
1000	93.8%	47.4%	23.1%	10.9%	9.0%	6.8%	6.2%
1200	95.7%	55.9%	31.2%	17.5%	15.1%	12.3%	4.3%
1400	96.9%	63.0%	38.9%	24.9%	22.1%	18.9%	3.1%
1600	97.7%	68.8%	46.0%	32.3%	29.4%	26.1%	2.3%
1800	98.3%	73.5%	52.3%	39.6%	36.6%	33.5%	1.7%
2000	98.7%	77.4%	58.0%	46.4%	43.5%	40.6%	1.3%

4.1. Passenger Cars

This section presents the calculation of incremental benefits associated with the proposed rule resulting from cases in which a passenger car strikes a pedestrian. Baseline test data for 16 passenger cars are presented in Appendix F. The 16 passenger cars included in the testing ranged from MY 1994 to MY 2021. As newer vehicles did not always outperform older vehicles, this test data is representative of the current fleet.

20

$$P(AIS1+F) = NORMDIST[\ln(HIC), 5.35669, 1.00948, TRUE]$$
$$P(AIS2+F) = NORMDIST[\ln(HIC), 6.96362, 0.84687, TRUE]$$
$$P(AIS3+F) = NORMDIST[\ln(HIC), 7.45231, 0.73998, TRUE]$$
$$P(AIS4+F) = NORMDIST[\ln(HIC), 7.65605, 0.60680, TRUE]$$
$$P(AIS5+F) = NORMDIST[\ln(HIC), 7.69637, 0.58750, TRUE]$$
$$P(Fatal) = NORMDIST[\ln(HIC), 7.73243, 0.55431, TRUE]$$

Table 145 shows the estimated probability of injury and fatality in each test of the baseline passenger. Table 146 shows the estimated probability of injury and fatality that would be expected for each impact test after compliance with the proposed rule. The percentage change in probability is estimated based on just meeting the requirement. That is, HIC values in the inner portion of the Hood Top equal to 2/3 of the Hood Area would be reduced to exactly 1000 and HIC values in the remainder of the Test Area would be reduced to exactly 1700.

Table 25 presents the percentage change in the probability of fatal and non-fatal injuries to the head in the case that a passenger car strikes a pedestrian, after compliance with the proposed rule. Overall, we find that the requirements specified in the proposed rule are estimated to be approximately 37.0 percent effective in mitigating fatalities.[21] There was relatively less reduction seen in lower severity injury estimates because of the conservative estimate that tests that exceeded the HIC limits would only be improved to meet the 1000 and 1700 HIC requirements and these HIC levels are still associated with a substantial probability of lower-severity head injury.

Table 25: Percentage Change in the Probability of Fatalities and Injuries for Passenger Cars

Injury Severity	Percentage Change in Probability
MAIS 1+F	0.4%
MAIS 2+F	6.1%
MAIS 3+F	15.1%
MAIS 4+F	28.5%
MAIS 5+F	31.9%
Fatalities	37.0%

Table 26 and Table 27 present the change in MAIS+F injuries as a result of the proposed rule for passenger cars. It is important to note that the table presents the number of injury cases by MAIS+F rather than MAIS, and are derived from data presented in Table 21While MAIS

[21] Calculations in Appendix F: Percent Change in Probability Calculations.

represents the number of non-fatal injuries at a specific severity, MAIS+F represents the number of non-fatal injuries at a specific severity or greater including fatalities. MAIS+F can be calculated by summing the non-fatal injuries and fatalities at specific severity level and greater. For example, MAIS 3+F would reflect the sum of non-fatal MAIS 3, MAIS 4, and MAIS 5 injuries, as well as fatalities.

For presentation purposes, these two tables are split. Table 26 presents the change in MAIS+F injuries MAIS 1+F to MAIS 3+F and Table 27 presents the change in MAIS+F injuries from MAIS 4+F to fatalities. The change in MAIS+F injuries is calculated by reflecting the percentage change in the probability of fatal and non-fatal injuries associated with the proposed rule (Table 25) on the MAIS+F injuries in the target population.

Table 26: Change in MAIS+F Injuries for Passenger Cars (MAIS 1+F to MAIS 3+F)

Injury Severity		MAIS 1+F			MAIS 2+F			MAIS 3+F		
Speed Limit (km/h/mph)		TP (Baseline)	% Reduction	Proposed Rule	TP (Baseline)	% Reduction	Proposed Rule	TP (Baseline)	% Reduction	Proposed Rule
<25	**<40**	421.7	0.4%	420.1	171.8	6.1%	161.3	77.5	15.1%	65.8
30	**48**	154.4	0.4%	153.8	62.8	6.1%	58.9	30.6	15.1%	26.0
35	**56**	292.6	0.4%	291.4	121.3	6.1%	113.9	55.5	15.1%	47.1
40+	**64+**	297.6	0.4%	296.4	100.5	6.1%	94.4	45.2	15.1%	38.4
Total		**1,166.3**	**-**	**1,161.7**	**456.5**	**-**	**428.5**	**208.9**	**-**	**177.3**

Note: Values may not sum due to rounding.

Table 27: Change in MAIS+F Injuries for Passenger Cars (MAIS 3+F to Fatality)

Injury Severity		MAIS 4+F			MAIS 5+F			Fatalities		
Speed Limit (km/h/mph)		TP (Baseline)	% Reduction	Proposed Rule	TP (Baseline)	% Reduction	Proposed Rule	TP (Baseline)	% Reduction	Proposed Rule
<25	**<40**	32.2	28.5%	23.0	28.0	31.9%	19.1	25.6	37.0%	16.1
30	**48**	15.9	28.5%	11.4	15.0	31.9%	10.2	14.5	37.0%	9.1
35	**56**	21.8	28.5%	15.6	20.4	31.9%	13.9	19.4	37.0%	12.3
40+	**64+**	16.3	28.5%	11.6	15.8	31.9%	10.8	15.6	37.0%	9.8
Total		**86.1**	**-**	**61.6**	**79.2**	**-**	**54.0**	**75.1**	**-**	**47.4**

Note: Values may not sum due to rounding.

Table 28 and Table 29 present the calculation of MAIS injuries resulting from passenger cars striking pedestrians under the baseline. MAIS injuries can be calculated by subtracting the number of MAIS+F one level above from the MAIS+F injuries in Table 21. For example, to calculate MAIS 1 injuries, we would subtract MAIS 2+F from the MAIS 1+F total.

Table 28: Baseline MAIS for Passenger Cars (MAIS 1 to MAIS 3)

Injury Severity		**MAIS 1**		**MAIS 2**		**MAIS 3**	
Speed Limit (mph/km/h)		**Calculation Based on MAIS+F**	**MAIS Total**	**Calculation Based on MAIS+F**	**MAIS Total**	**Calculation Based on MAIS+F**	**MAIS Total**
<25	**<40**	421.7 – 171.8	249.9	171.8 – 77.5	94.3	77.5 – 32.2	45.4
30	**48**	154.4 – 62.8	91.6	62.8 – 30.6	32.1	30.6 – 15.9	14.7
35	**56**	292.6 – 121.3	171.2	121.3 – 55.5	65.8	55.5 – 21.8	33.7
40+	**64+**	297.5 – 100.5	197.0	100.5 – 45.2	55.3	45.2 – 16.3	28.9
Total		-	**709.8**	-	**247.6**	-	**122.8**

Note: Values may not sum due to rounding.

Table 29: Baseline MAIS for Passenger Cars (MAIS 4 to Fatalities)

Injury Severity		**MAIS 4**		**MAIS 5**		**Fatality**	
Speed Limit (mph/km/h)		**Calculation Based on MAIS+F**	**MAIS Total**	**Calculation Based on MAIS+F**	**MAIS Total**	**Calculation Based on MAIS+F**	**MAIS Total**
<25	**<40**	32.2 – 28.0	4.1	28.0 – 25.6	2.4	-	25.6
30	**48**	15.9 – 15.0	0.9	15.0 – 14.5	0.5	-	14.5
35	**56**	21.8 – 20.4	1.4	20.4 – 19.4	0.9	-	19.4
40+	**64+**	16.3 – 15.8	0.4	15.8 – 15.6	0.3	-	15.6
Total		-	**6.9**	-	**4.1**	-	**75.1**

Note: Values may not sum due to rounding.

Table 30 and Table 31 present the calculation of MAIS injuries resulting from passenger cars striking pedestrians under the proposed rule. MAIS injuries can be calculated by subtracting the number of MAIS+F one level above from the MAIS+F injuries.

Table 30: Proposed Rule MAIS for Passenger Cars (MAIS 1 to MAIS 3)

Injury Severity		MAIS 1		MAIS 2		MAIS 3	
Speed Limit (mph/km/h)		Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total
<25	<40	420.1 – 161.3	258.7	161.3 – 65.8	95.5	65.8 – 23.0	42.8
30	48	153.8 – 58.9	94.9	58.9 – 26.0	32.9	26.0 – 11.4	14.6
35	56	291.4 – 113.9	177.5	113.9 – 47.1	66.8	47.1 – 15.6	31.5
40+	64+	296.4 – 94.4	202.0	94.4 – 38.4	56.0	38.4 – 11.6	26.7
Total		-	**733.1**	-	**251.2**	-	**115.7**

Note: Values may not sum due to rounding.

Table 31: Proposed Rule MAIS for Passenger Cars (MAIS 4 to Fatalities)

Injury Severity		MAIS 4		MAIS 5		Fatality	
Speed Limit (mph/km/h)		Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total
<25	<40	23.0 – 19.1	3.9	19.1 – 16.1	2.9	-	16.1
30	48	11.4 – 10.2	1.2	10.2 – 9.1	1.1	-	9.1
35	56	15.6 – 13.9	1.7	13.9 – 12.3	1.6	-	12.3
40+	64+	11.6 – 10.8	0.8	10.8 – 9.8	1.0	-	9.8
Total		-	**7.6**	-	**6.6**	-	**47.4**

Note: Values may not sum due to rounding.

Table 32 and Table 33 present the total incremental benefits for passenger cars. Incremental benefits are the difference in MAIS injuries between the baseline and the proposed rule. As a result of the proposed rule, a total of approximately 27.8 fatalities resulting from cases in which a passenger car strikes a pedestrian would be mitigated. Note that the countermeasures to meet the requirements specified in the proposed rule mitigate fatalities which become less severe non-fatal injuries and mitigate more severe non-fatal injuries which become less severe injuries. Although the net total of non-fatal injuries from MAIS 1 to MAIS 5 increase under the proposed rule due to the trickle-down of those fatalities and non-fatal injuries, overall there is a benefit at each MAIS level.

Table 32: Total Annual Incremental Benefits for Passenger Cars (MAIS 1 to MAIS 3)

Injury Severity		MAIS 1			MAIS 2			MAIS 3		
Speed Limit (mph/km/h)		Baseline	Proposed Rule	Benefits	Baseline	Proposed Rule	Benefits	Baseline	Proposed Rule	Benefits
<25	**<40**	249.9	258.7	-8.9	94.3	95.5	-1.2	45.4	42.8	2.6
30	**48**	91.6	94.9	-3.2	32.1	32.9	-0.8	14.7	14.6	0.1
35	**56**	171.2	177.5	-6.3	65.8	66.8	-1.0	33.7	31.5	2.2
40+	**64+**	197.0	202.0	-5.0	55.3	56.0	-0.7	28.9	26.7	2.2
Total		**709.8**	**733.1**	**-23.3**	**247.6**	**251.2**	**-3.7**	**122.8**	**115.7**	**7.0**

Note: Values may not sum due to rounding.

Table 33: Total Annual Incremental Benefits for Passenger Cars (MAIS 4 to Fatalities)

Injury Severity		MAIS 4			MAIS 5			Fatality		
Speed Limit (mph/km/h)		Baseline	Proposed Rule	Benefits	Baseline	Proposed Rule	Benefits	Baseline	Proposed Rule	Benefits
<25	**<40**	4.1	3.9	0.2	2.4	2.9	-0.5	25.6	16.1	9.5
30	**48**	0.9	1.2	-0.2	0.5	1.1	-0.6	14.5	9.1	5.4
35	**56**	1.4	1.7	-0.3	0.9	1.6	-0.7	19.4	12.3	7.2
40+	**64+**	0.4	0.8	-0.4	0.3	1.0	-0.7	15.6	9.8	5.8
Total		**6.9**	**7.6**	**-0.7**	**4.1**	**6.6**	**-2.5**	**75.1**	**47.4**	**27.8**

Note: Values may not sum due to rounding.

4.2. LTVs

This section presents the calculation of incremental benefits associated with the proposed rule resulting from cases in which an LTV strikes a pedestrian. Baseline test data for 24 LTV are presented in Appendix F. The 24 LTVs included in the testing ranged from MY 1999 to MY 2020. As newer vehicles did not always outperform older vehicles, this test data is representative of the current fleet.

Table 148 shows the estimated probability of injury and fatality in each test on those LTVs.

Table 149 shows the estimated probability of injury and fatality that would be expected for each impact test after compliance with the proposed rule. It was estimated that HIC values in the inner portion of the Hood Top equal to 2/3 of the Hood Area would be reduced to 1000 and HIC values in the remainder of the Test Area would be reduced to 1700.

Table 34 presents the percentage change in the probability fatal and non-fatal injuries to the head in the case that an LTV strikes a pedestrian for between the baseline and proposed. Overall, the requirements specified in the proposed rule are 43.0 percent effective in mitigating fatalities.[22] As with passenger cars, less change was seen in the probability of lower-severity injuries.

Table 34: Percentage Change in the Probability of Fatal and Non-Fatal Injuries for LTVs

Injury Severity	**Percentage Change in Probability**
MAIS 1+F	0.7%
MAIS 2+F	9.5%
MAIS 3+F	20.8%
MAIS 4+F	34.9%
MAIS 5+F	38.2%
Fatalities	43.0%

Table 35 and Table 36 present the change in MAIS+F injuries as a result of the proposed rule for

[22] Calculations in Appendix F: Percent Change in Probability Calculations.

LTVs. It is important to note that the table presents the number of non-fatal injuries by MAIS+F rather than MAIS and are derived from data presented in Table 22 For presentation purposes, these two tables are split. Table 35 presents the change in MAIS+F injuries MAIS 1+F to MAIS 3+F and Table 36 presents the change in MAIS+F injuries from MAIS 4+F to fatalities. The change in MAIS+F injuries is calculated by reflecting the percentage change in the probability of fatal and non-fatal injuries associated with the proposed rule (Table 34) on the MAIS+F injuries in the target population.

Table 35: Change in MAIS+F Injuries for LTVs (MAIS 1+F to MAIS 3+F)

Injury Severity		MAIS 1+F			MAIS 2+F			MAIS 3+F		
Speed Limit (mph/km/h)		TP (Baseline)	% Reduction	Proposed Rule	TP (Baseline)	% Reduction	Proposed Rule	TP (Baseline)	% Reduction	Proposed Rule
<25	**<40**	395.6	0.7%	392.7	227.3	9.5%	205.6	101.8	20.8%	80.6
30	**48**	129.9	0.7%	128.9	76.8	9.5%	69.5	37.5	20.8%	29.7
35	**56**	261.9	0.7%	259.9	149.7	9.5%	135.4	65.3	20.8%	51.7
40+	**64+**	240.6	0.7%	238.8	120.3	9.5%	108.8	52.5	20.8%	41.6
Total		**1,028.0**	**-**	**1,020.4**	**574.1**	**-**	**519.3**	**257.1**	**-**	**203.5**

Note: Values may not sum due to rounding.

Table 36: Change in MAIS+F Injuries for LTVs (MAIS 3+F to Fatality)

Injury Severity		MAIS 4+F			MAIS 5+F			Fatalities		
Speed Limit (mph/km/h)		TP (Baseline)	% Reduction	Proposed Rule	TP (Baseline)	% Reduction	Proposed Rule	TP (Baseline)	% Reduction	Proposed Rule
<25	**<40**	44.2	34.9%	28.8	39.2	38.2%	24.2	36.4	43.0%	20.7
30	**48**	19.1	34.9%	12.5	18.0	38.2%	11.1	17.3	43.0%	9.9
35	**56**	24.2	34.9%	15.8	22.5	38.2%	13.9	21.5	43.0%	12.3
40+	**64+**	17.8	34.9%	11.6	17.3	38.2%	10.7	17.0	43.0%	9.7
Total		**105.3**	**-**	**68.6**	**97.0**	**-**	**59.9**	**92.2**	**-**	**52.5**

Note: Values may not sum due to rounding.

Table 37 and Table 38 present the calculation of MAIS injuries resulting from LTVs striking pedestrians under the baseline. MAIS injuries can be calculated by subtracting the number of MAIS+F one level above from the MAIS+F injuries. For example, to calculate MAIS 1 injuries, we would subtract MAIS 2+F from the MAIS 1+F total.

Table 37: Baseline MAIS for LTVs (MAIS 1 to MAIS 3)

Injury Severity		MAIS 1		MAIS 2		MAIS 3	
Speed Limit (mph/km/h)		Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total
<25	<40	395.6 – 227.3	168.4	227.3 – 101.8	125.5	101.8 – 44.2	57.6
30	48	129.9 – 76.8	53.0	76.8 – 37.5	39.3	37.5 – 19.1	18.4
35	56	261.9 – 149.7	112.2	149.7 – 65.3	84.4	65.3 – 24.2	41.1
40+	64+	240.6 – 120.3	120.3	120.3 – 52.5	67.8	52.5 – 17.8	34.7
Total		**-**	**453.9**	**-**	**317.0**	**-**	**151.7**

Note: Values may not sum due to rounding.

Table 38: Baseline MAIS for LTVs (MAIS 4 to Fatalities)

Injury Severity		MAIS 4		MAIS 5		Fatality	
Speed Limit (mph/km/h)		Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total
<25	<40	44.2 – 39.2	5.0	39.2 – 36.4	2.8	-	36.4
30	48	19.1 – 18.0	1.1	18.0 – 17.3	0.7	-	17.3
35	56	24.2 – 22.5	1.7	22.5 – 21.5	1.0	-	21.5
40+	64+	17.8 – 17.3	0.5	17.3 – 17.0	0.3	-	17.0
Total		**-**	**8.4**	**-**	**4.8**	**-**	**92.2**

Note: Values may not sum due to rounding.

Table 39 and Table 40 present the calculation of MAIS injuries resulting from LTVs striking pedestrians under the proposed rule. MAIS injuries can be calculated by subtracting the number of MAIS+F one level above from the MAIS+F injuries.

Table 39: Proposed Rule MAIS for LTVs (MAIS 1 to MAIS 3)

Injury Severity		**MAIS 1**		**MAIS 2**		**MAIS 3**	
Speed Limit (mph/km/h)		**Calculation Based on MAIS+F**	**MAIS Total**	**Calculation Based on MAIS+F**	**MAIS Total**	**Calculation Based on MAIS+F**	**MAIS Total**
<25	**<40**	392.7 – 205.6	187.1	205.6 – 80.6	125.0	80.6 – 28.8	51.8
30	**48**	128.9 – 69.5	59.4	69.5 – 29.7	39.8	29.7 – 12.5	17.3
35	**56**	259.9 – 135.4	124.5	135.4 – 51.7	83.8	51.7 – 15.8	35.9
40+	**64+**	238.8 – 108.8	130.0	108.8 – 41.6	67.2	41.6 – 11.6	30.0
Total		**-**	**501.1**	**-**	**315.8**	**-**	**134.9**

Note: Values may not sum due to rounding.

Table 40: Proposed Rule MAIS for LTVs (MAIS 4 to Fatalities)

Injury Severity		**MAIS 4**		**MAIS 5**		**Fatality**	
Speed Limit (mph/km/h)		**Calculation Based on MAIS+F**	**MAIS Total**	**Calculation Based on MAIS+F**	**MAIS Total**	**Calculation Based on MAIS+F**	**MAIS Total**
<25	**<40**	28.8 – 24.2	4.6	24.2 – 20.7	3.5	-	20.7
30	**48**	12.5 – 11.1	1.3	11.1 – 9.9	1.2	-	9.9
35	**56**	15.8 – 13.9	1.9	13.9 – 12.3	1.7	-	12.3
40+	**64+**	11.6 – 10.7	0.9	10.7 – 9.7	1.0	-	9.7
Total		**-**	**8.7**	**-**	**7.4**	**-**	**52.5**

Note: Values may not sum due to rounding.

Table 41 and Table 42 present the total incremental benefits for LTVs. Incremental benefits are the difference in MAIS injuries between the baseline and the proposed rule. As a result of the proposed rule, a total of 39.7 fatalities resulting from cases in which an LTV strikes a pedestrian would be mitigated. Note that the countermeasures to meet the requirements specified in the proposed rule mitigate fatalities which become less severe non-fatal injuries and mitigate more severe non-fatal injuries which become less severe injuries. Although the net total of non-fatal injuries from MAIS1 to MAIS 5 increase under the proposed rule due to the trickle-down of those fatalities and non-fatal injuries, overall there is a benefit at each MAIS level.

Table 41: Total Annual Incremental Benefits for LTVs (MAIS 1 to MAIS 3)

Injury Severity		MAIS 1			MAIS 2			MAIS 3		
Speed Limit (mph/km/h)		**Baseline**	**Proposed Rule**	**Benefits**	**Baseline**	**Proposed Rule**	**Benefits**	**Baseline**	**Proposed Rule**	**Benefits**
<25	**<40**	168.4	187.1	-18.8	125.5	125.0	0.5	57.6	51.8	5.8
30	**48**	53.0	59.4	-6.4	39.3	39.8	-0.5	18.4	17.3	1.1
35	**56**	112.2	124.5	-12.3	84.4	83.8	0.7	41.1	35.9	5.2
40+	**64+**	120.3	130.0	-9.7	67.8	67.2	0.5	34.7	30.0	4.7
Total		**453.9**	**501.1**	**-47.2**	**317.0**	**315.8**	**1.2**	**151.7**	**134.9**	**16.8**

Note: Values may not sum due to rounding.

Table 42: Total Annual Incremental Benefits for LTVs (MAIS 4 to Fatalities)

Injury Severity		MAIS 4			MAIS 5			Fatality		
Speed Limit (mph/km/h)		**Baseline**	**Proposed Rule**	**Benefits**	**Baseline**	**Proposed Rule**	**Benefits**	**Baseline**	**Proposed Rule**	**Benefits**
<25	**<40**	5.0	4.6	0.4	2.8	3.5	-0.7	36.4	20.7	15.6
30	**48**	1.1	1.3	-0.2	0.7	1.2	-0.6	17.3	9.9	7.5
35	**56**	1.7	1.9	-0.2	1.0	1.7	-0.6	21.5	12.3	9.3
40+	**64+**	0.5	0.9	-0.4	0.3	1.0	-0.7	17.0	9.7	7.3
Total		**8.4**	**8.7**	**-0.3**	**4.8**	**7.4**	**-2.6**	**92.2**	**52.5**	**39.7**

Note: Values may not sum due to rounding.

4.3. Total

Table 43 presents the total annual incremental benefits for both vehicle types. As a result of the proposed rule, approximately 67.4 fatalities resulting from either a passenger car or LTV striking a pedestrian would be mitigated. As those fatalities are mitigated, the number of non-fatal injuries across the MAIS 1-5 scale increases by approximately the same amount.

Table 43: Total Annual Incremental Benefits

Injury Severity	Benefits by Vehicle Type		Total Benefits
	Passenger Cars	LTVs	
MAIS 1	-23.3	-47.2	-70.5
MAIS 2	-3.7	1.2	-2.5
MAIS 3	7.0	16.8	23.9
MAIS 4	-0.7	-0.3	-1.1
MAIS 5	-2.5	-2.6	-5.1
Fatalities	27.8	39.7	67.4

Note: Values may not sum due to rounding. Negative values represent an increase in the number of injuries at that specific severity.

Due to data limitations, this analysis may underestimate benefits. More specifically, this analysis may underestimate benefits because it only estimates effectiveness at the speeds reflected in the test data. Therefore, our analysis reflects zero effectiveness in any case with estimated head impact speed over test impact speed of 40 km/h (vehicle to pedestrian impact speed of over 46 km/h). However, it is likely that there would be some level of effectiveness and, therefore, safety benefits at speeds above those included in the testing conducted by the agency.

Furthermore, due to a lack of test data for countermeasures that would reduce HIC in failing locations, the benefits estimated in this analysis are based on just meeting the absolute minimum performance to meet the requirements specified in the proposed rule. As it is likely that those countermeasures would result in greater injury reductions than just the very minimum of meeting the requirement (e.g., reducing to exactly HIC 1000 or 1700 where applicable), this analysis may underestimate benefits. Similarly, other data limitations may overestimate benefits such as using target population cases where there were MAIS injuries other than head injuries (in addition to the MAIS head injuries from hood top impacts).

4.4. Summary

This chapter presented the incremental benefits associated with the proposed rule. Incremental benefits are those fatalities and non-fatal injuries mitigated as a result of meeting the requirements specified in the proposed rule. As the benefits of this proposed rule are the result of crash mitigation rather than crash avoidance, we note that fatalities become non-fatal injuries and more severe non-fatal injuries become less severe non-fatal injuries. As a result of the proposed rule, approximately 67.4 fatalities would be mitigated annually.

5. Costs

This chapter presents the incremental costs associated with requirements specified in the proposed rule. The following sections present the affected universe and the incremental cost per vehicle associated with meeting the requirements specified in the proposed rule, respectively. The last section then presents the total annual cost based on the number of vehicles that would incur the incremental costs associated with the meeting the requirements specified in the proposed rule.

5.1. Affected Universe

This section presents the affected universe which is the number of vehicles subject to the proposed rule annually. Vehicles subject to the requirements specified in the proposed rule are all newly manufactured light vehicles. Therefore, this analysis makes use of annual sales data between calendar year (CY) 2011-2020 to estimate the number of vehicles subject to the proposed rule.

Table 44 presents the annual sales of new light vehicles for 2011-2020.[23] Over the ten-year

[23] Davis, S. C., Diegel, S. W., & Boundy, R. G. (2021). Transportation energy data book: Edition 39. Retrieved from: https://tedb.ornl.gov/wp-content/uploads/2021/02/TEDB_Ed_39.pdf.

period, an average of 15.7 million light vehicles were sold annually, of which approximately 40 percent were cars and 60 percent were light trucks.

Table 44: Annual Sales of New Light Vehicles (thousands)

Year	**Cars**	**Light Trucks**	**Total Light Vehicle Sales**
2011	6,093	6,449	12,542
2012	7,245	6,975	14,220
2013	7,586	7,693	15,279
2014	7,708	8,484	16,192
2015	7,529	9,578	17,107
2016	6,883	10,296	17,179
2017	6,089	10,738	16,827
2018	5,310	11,609	16,919
2019	4,720	11,911	16,630
2020	3,402	10,712	14,114
Annual Average *(% of total LV sales)*	**6,257** *(39.8%)*	**9,445** *(60.2%)*	**15,701** *(100%)*

.

5.2. Incremental Costs

This section presents the incremental cost per vehicle to meet the requirements specified in the proposed rule. To meet the requirements specified in the proposed rule, vehicle manufacturers could potentially incur a one-time cost associated with redesigning vehicle hoods to be in compliance with the proposed rule. Many manufacturers of vehicles that would be subject to the proposed rule also manufacture vehicles in the European (EU) market where the EU interpretation of GTR 9 (GTR 9 Amendment 3) is already established. As a result of the similarity of the EU interpretation of GTR 9 and the proposed rule, it is expected that vehicle manufacturers would need to make very minor changes or changes with very minor costs to their hoods to be in compliance with the proposed rule. Therefore, the potential one-time cost associated with redesigning vehicle hoods to meet the requirements specified in the proposed rule are expected to be negligible. Furthermore, that potential one-time cost is even more negligible when considered on a per-vehicle basis, across design cycles, and given the lead time specified in the proposed rule. NHTSA requests comment on this assumption that redesign costs are expected to be minimal.

This analysis also considers the impact that the design changes or hardware used to meet the requirements may have on the cost and weight of the vehicles subject to the proposed rule. The cost and weight estimates used in this analysis are from: Cost and Weight Analysis for Pedestrian Protection completed in 2014 for NHTSA by Waltonen Engineering, Inc.[24] The study compared vehicles designed for the EU market where GTR 9 Amendment 3 is already established with the same or similar vehicles designed for the North American (NA) market which would not currently meet the GTR.

The teardown study included three versions of the Ford Focus: 2011 Ford Focus, 2012 Ford Focus designed for the EU market, and 2012 Ford Focus designed for the NA market. The 2011 Ford Focus was designed for the NA market without sales in EU. Therefore, the assumption is made that there are no GTR-driven pedestrian protection features designed into the front end of that particular vehicle. The 2012 EU Ford Focus is the platform vehicle that is modified for global sales. Since that version was specifically designed for sale in the EU market, it is assumed that GTR-driven pedestrian protection features are designed into the vehicle front end. The 2012 NA version of the Ford Focus is based on the EU platform with slight design modifications so the vehicle meets NA regulations.

Lastly, we note that the study also compared the cost and weight differences between the 2012 Ford Ranger for the EU market and the 2013 Ford F-150 for the NA market. However, this PRIA did not make use of the cost and weight differences between those two vehicles as the differences in cost and weight could not be completely attributed to pedestrian protection

[24] Department of Transportation, National Highway Traffic Safety Administration, Office of Acquisition Management (NPO-320), West Building 51-117 1200 New Jersey Avenue, SE, Washington, DC 20590, Contract Number: DTNH22-10-D-00194/0003. Cost and Weight Analysis for Pedestrian Protection. Waltonen Engineering, Inc. 31330 Mound Rd. Warren, Michigan 48092. November 26, 2014.

features.

Table 45 summarizes the findings of the teardown study for three versions of the Ford Focus. When comparing both versions of the 2012 Ford Focus, the study found that majority of the parts were similar between EU and NA versions and had carryover part numbers. Some of the differences were in non-pedestrian protection areas and most likely due to specific regulations of the area for which the vehicle was to be sold. The hood dimensions of the 2011 Ford Focus designed for the NA market were different from both 2012 models. The study found that the 2012 EU and NA Focus Hood Assemblies had no perceived differences in design or assembly. Therefore, we do not account for any costs associated with differences in hardware. However, when comparing the 2012 EU and NA Focus hood Assemblies, although the hood dimensions were the same, the EU version weighed a pound greater than the NA version.

Table 45: Hood Assembly Weights by Model

Vehicle	Hood Dimensions (inches)	Weight (lbs.)
2011 Ford Focus NA	57.75 x 43 x 4	26.8
2012 Ford Focus NA	62.06 x 41.12 x 5.93	26.5
2012 Ford Focus EU	62.06 x 41.12 x 5.93	27.5

Based on the findings of the teardown study, this analysis estimates the impact that the incremental weight of one pound may have on fuel economy. Equation (1) is the standard formula for estimating the impact on fuel economy from weight:

$$Proposed\ Rule\ Fuel\ Economy = \frac{Baseline\ vehic\quad weigh}{Proposed\ Rule\ vehicle\ weigh}^{0.8}\ x\ Baseline\ fuel\ economy \quad (1).$$

This analysis establishes the baseline vehicle weight for passenger cars and LTVs taking into account average curb weight for MY 2021-2022 based on the Polk data. For passenger cars, the average curb weight is 3,288 lbs. and the baseline fuel economy is 24.2 miles per gallon (mpg). Reflecting an increase in weight of one pound in equation (1), we find that the fuel economy for passenger cars under the proposed rule would be approximately 24.194 mpg. Furthermore, in assessing the costs associated with the impact that the proposed rule may have on fuel economy, this analysis makes use of the projected price of gasoline is from the Annual Energy Outlook 2022.[25] Taking into account the vehicle miles traveled (VMT) over the course of a passenger car's lifespan (see Appendix A), the incremental cost associated with that the proposed rule may have on fuel economy is estimated at approximately $4.19.[26]

For LTVs, the average curb weight is 4,354 lbs. and the baseline fuel economy is 17.5 mpg. Reflecting an increase in weight of one pound in equation (1), we find that the fuel economy for LTVs under the proposed rule would be approximately 17.497 mpg. Taking into account the VMT of the course of a LTV's lifespan (see Appendix A), the incremental cost that the proposed rule may have on fuel economy is estimated at approximately $4.96.

This analysis takes into account the timing in which costs are incurred. As the incremental costs associated with the impact on fuel economy are incurred over the course of the vehicle's lifespan, we discount those costs to reflect their present value. Consistent with the OMB's guidance, this analysis uses discount rates of three and seven percent.

Table 46 presents the discount factor for both passenger cars and LTVs by discount rate (see Appendix A for details). For passenger cars, the discount factor is 0.8354 and 0.6816 for a three and seven percent discount rate, respectively. For LTVs, the discount factor is 0.8216 and 0.6626 for a three and seven percent discount rate, respectively.

---

[25] Annual Energy Outlook 2022 Table: Table 12. Petroleum and Other Liquids Prices. U.S. Energy Information Administration - EIA - Independent Statistics and Analysis. https://www.eia.gov/outlooks/aeo/. Note that gasoline prices were presented in 2021 dollars and then updated to reflect 2020 dollars as presented in this analysis.

[26] See Appendix D: Weight Impacts on Fuel Economy for detailed calculations.

Table 46: Discount Factor by Discount Rate and Vehicle Type

Vehicle Type	Discount Rate	
	3%	7%
Passenger Car	0.8354	0.6816
Light Truck	0.8216	0.6626

Reflecting those discount factors on the estimated incremental costs that are incurred over the course of a vehicle's lifespan, Table 47 presents the present value of the incremental cost when discounted at three and seven percent. For passenger cars, we find that the present value of the incremental cost associated with impacts to fuel economy is $3.50 and $2.86 when discounted at three and seven percent, respectively. When discounted at three and seven percent, the present value of the incremental cost associated with impacts to fuel economy for LTVs is $4.08 and $3.29, respectively.

Table 47: Discounted Lifetime per Vehicle Fuel Economy Cost

Vehicle Type	Undiscounted	Discounted at 3%	Discounted at 7%
Passenger Car	$4.19	$3.50	$2.86
LTV	$4.96	$4.08	$3.29

Table 48 presents the total annual cost associated with the proposed rule when discounted at three and seven percent. The total annual cost reflects the potential impact that the proposed rule may have on fuel economy over the course a of a vehicle's lifespan. Furthermore, we also note that these costs are equal to the annual cost associated with the proposed rule when all light vehicles subject to the proposed rule are in compliance. The total cost for each vehicle type is calculated by applying the per vehicle cost to the number of vehicles impacted by the proposed rule.

When discounted at three and seven percent, the total fuel economy cost for passenger cars is approximately $21.9 million and $17.9 million, respectively. When discounted at three and seven percent, the total fuel economy cost for LTVs is approximately $38.5 million and $31.1 million, respectively. Overall, when discounted at three and seven percent, the total annual cost associated with the proposed rule is approximately $60.3 million and $48.9 million, respectively. As this analysis relies on limited data to estimate costs, we request comment on the costs associated with meeting the requirements specified in the proposed rule.

Table 48: Total Annual Cost

Category	**Number of Vehicles Impacted**	**Per Vehicle Cost**		**Total Fuel Economy Cost**	
		Discounted at 3%	**Discounted at 7%**	**Discounted at 3%**	**Discounted at 7%**
Passenger Car	6,257,000	$3.50	$2.86	$21,923,153	$17,887,026
LTV	9,445,000	$4.08	$3.29	$38,507,293	$31,055,176
Total Annual Cost				**$60,430,447**	**$48,942,202**

Note: Values may not sum due to rounding.

5.3. Unquantified Costs

The requirements specified in the proposed rule may have other cost impacts that lack sufficient data to be quantified. The requirements specified in the proposed rule may impose potential restrictions on vehicle design. These potential restrictions would be specific to the front end or profile of applicable vehicles when vehicles must have an adequate gap between the hood and hinges, as well as other components used to meet the HIC requirement. As a result, these restrictions may have impacts on the sales of such vehicles. However, there is a lack of data to quantify the potential impact that such design restrictions may have on vehicle sales. We request comment on these potential unquantified costs.

5.4. Summary

This chapter presented the incremental costs associated with the requirements specified in the proposed rule. The total annual cost associated with the proposed rule is comprised of the costs associated with the impact that the incremental weight may have on fuel economy. As the costs associated with fuel economy are incurred over the course of the vehicle’s lifetime, those costs are discounted to reflect their present value. When discounted at three and seven percent, the total annual cost associated with the proposed rule is estimated at approximately $60.4 million and $48.9 million, respectively. Lastly, we acknowledge that this cost analysis was based on limited data and request comment on the various assumptions and data sources employed in this chapter.

6. Lead Time

This chapter discusses the lead time for the implementation of the requirements specified in the proposed rule. The proposed effective date of the rule is the first September 1, two years after publication of the final rule. Thus, the proposed rule specifies a minimum lead time of two. Additionally, multistage manufacturers and alterers would be allowed an additional year of lead time (49 CFR § 571.8(b)).

Many passenger cars, minivans, cross-over vehicles, and other vehicles under 3,500 kg (7,716 lbs.) GVWR sold in the U.S share similar global designs as models that are currently sold in the EU. As a result, most vehicle manufacturers would already be familiar with similar requirements based on the requirements already established in the EU. However, a final rule resulting from the NPRM may differ in its requirements from the GTR as implemented by other countries, so the proposed rule allows manufacturers two years of lead time to assure that manufacturers have time to adjust their designs to meet the NHTSA standard. Also, a two-year lead time is proposed to enable manufacturers of vehicles unique to the U.S. market, such as large SUVs and pickup trucks, sufficient time to meet the standard.

7. Cost-Effectiveness and Net Benefits

This chapter presents the cost-effectiveness and benefit-cost analyses for the proposed rule. Cost-effectiveness and benefit-cost analyses provide useful information about the relative performance of regulatory alternatives. Impacts associated with regulatory alternatives are broadly categorized into benefits and costs and are then converted from impact quantities, such as fatal crashes, into dollar values. As a result, decision-makers are able to make direct comparisons across regulatory alternatives and identify those that achieve the most effective use of available resources. Furthermore, both cost-effectiveness and benefit-cost analyses must account for the timing in which impacts are realized. That is, these analyses must consider impacts in the present as well as those in all relevant future years. To account for the greater value of impacts occurring in the present relative to those occurring further in the future, future impacts are discounted so that all values are represented as present values. As the benefits and costs associated with the proposed rule are realized over the course of a vehicle's lifespan, we discount them to reflect their present value. Consistent with the OMB's guidance, these analyses use discount rates of three and seven percent (see Table 46).

The following sections detail the calculation of the measures employed in the cost-effectiveness and benefit-cost analyses. These analyses make use of the benefits and costs presented in previous chapters to calculate the measures used to compare and categorize regulatory alternatives.

7.1. Cost-Effectiveness Analysis

The purpose of a cost-effectiveness analysis is to compare a set of regulatory alternatives with the same primary outcome in order to identify the most effective use of the resources available. A regulatory alternative is considered to be cost-effective if the estimated cost per unit of change is less than an appropriate benchmark. While cost-effectiveness measures serve as a means of comparing regulatory alternatives, it must be noted that the results of a benefit-cost analysis are based on averages and, therefore, must be treated with great care. Furthermore, the most cost-effective regulatory alternative may not always maximize net benefits.

In order to make a comparison across alternatives, the primary outcome of the regulatory action must be quantified on a single numerical index. As the proposed rule addresses an issue of safety, the objective is to mitigate fatalities and non-fatal injuries which are not measured on the same scale. Furthermore, the fatalities and non-fatal injuries mitigated as a result of the proposed rule trickle-down into less severe non-fatal injuries. Therefore, in order to compare outcomes across regulatory alternatives, fatalities and non-fatal injuries must be reflected on a single numerical index. Equivalent lives saved is a single numerical index that reflects both fatalities and non-fatal injuries and, therefore, is used to measure and compare the benefits associated with regulatory alternatives that address an issue of safety.

To calculate the equivalent lives saved, non-fatal injuries must be expressed in terms of fatalities. Non-fatal injuries are expressed in terms of equivalent fatalities by comparing the value of preventing non-fatal 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 non-fatal injuries. By applying the relative disutility factors based on the fraction of VSL to the number of non-fatal injuries by MAIS level, the number of non-fatal injuries can be converted to equivalent fatalities.

Table 49 presents the relative disutility factors by injury severity level reported on the MAIS scale.[27] By applying the fraction of VSL to the number of non-fatal injuries by MAIS level, the number of non-fatal injuries can be converted to equivalent fatalities.

[27] "Revised Departmental Guidance, Treatment of Value of Preventing Fatalities and Injuries in Preparing Economic Analyses", March 2021.

Table 49: Relative Disutility Factors by Injury Severity Level used to Convert Non-fatal Injuries to Equivalent Fatalities

MAIS Level	Injury Severity	Fraction of VSL
MAIS 1	Minor	0.003
MAIS 2	Moderate	0.047
MAIS 3	Serious	0.105
MAIS 4	Severe	0.266
MAIS 5	Critical	0.593
MAIS 6	Unsurvivable	1.000

Table 50 presents the conversion of injury benefits by MAIS level to equivalent fatalities. Based on this conversion, the proposed rule would prevent approximately 26.6 and 39.7 equivalent fatalities resulting from head injuries in cases that a passenger car or LTV strikes a pedestrian, respectively.

Table 50: Conversion of MAIS Injury to Equivalent Fatalities

MAIS Level	Passenger Cars			LTVs		
	Benefits	Fraction of VSL	Equivalent Fatalities	Benefits	Fraction of VSL	Equivalent Fatalities
MAIS 1	-23.3	0.003	-0.070	-47.2	0.003	-0.141
MAIS 2	-3.7	0.047	-0.174	1.2	0.047	0.056
MAIS 3	7.0	0.105	0.740	16.8	0.105	1.766
MAIS 4	-0.7	0.266	-0.190	-0.3	0.266	-0.093
MAIS 5	-2.5	0.593	-1.478	-2.6	0.593	-1.532
Fatal	27.8	1.000	27.786	39.7	1.000	39.662
Total			**26.615**			**39.718**

Note: Values may not sum due to rounding.

A cost-effectiveness analysis must take into account the timing in which benefits and costs are realized. Therefore, this analysis considers the benefits and costs associated with the requirements specified in the proposed rule over the lifetime of one MY's production.[28] As was the case with the incremental costs associated with impacts to fuel economy, the benefits associated with the proposed rule are realized over the course of a vehicle's lifespan. Therefore, total equivalent fatalities prevented are discounted to reflect their present value.

Table 51 presents the calculation of discounted equivalent fatalities. When discounted at three and seven percent, the present value of the equivalent fatalities ranges are approximately 54.87 and 44.46, respectively.

Table 51: Discounted Equivalent Fatalities

Category	**Discounted at 3%**			**Discounted at 7%**		
	Equivalent Fatalities	**Adjustment Factor**	**Discounted Equivalent Fatalities**	**Equivalent Fatalities**	**Adjustment Factor**	**Discounted Equivalent Fatalities**
PCs	26.62	0.8354	22.23	26.62	0.6816	18.14
LTVs	39.72	0.8216	26.32	39.72	0.6626	26.32
Total			**54.87**			**44.46**

Note: Values may not sum due to rounding.

As the unit of change used in this cost-effectiveness analysis is the number of equivalent lives saved, a regulatory alternative is considered to be cost-effective if the average cost per equivalent life saved is less than the comprehensive economic cost of a fatality. That is, the regulatory alternative yields safety benefits at a lower cost than the benchmark value for those benefits. The comprehensive economic cost of a fatality takes into account a variety of cost components including medical, Emergency Medical Services, market productivity, household productivity, insurance administration, workplace, legal, congestion, travel delay, and the nontangible value of

[28] For details on this approach see Appendix B: Model Year and Calendar Year Comparison.

physical pain and loss of quality of life (i.e., quality adjusted life years, QALYs).

Table 52 presents the cost per equivalent life saved associated with the requirements specified in the proposed rule. When discounted at both three and seven percent, the cost per equivalent life saved is approximately $1.10 million. As the cost per equivalent life for both discount rates is less than the comprehensive economic cost of a fatality which is estimated at approximately $11.9 million in 2020 dollars, the proposed rule is considered to be cost-effective.

Table 52: Cost per Equivalent Life Saved

Discount Rate	Equivalent Lives Saved	Total Cost (Millions)	Cost per Equivalent Life Saved (Millions)
3%	54.87	$60.43	$1.10
7%	44.46	$48.94	$1.10

Note: Values may not sum due to rounding.

7.2. Benefit-Cost Analysis

Net benefits are used as an absolute measure of the returns offered by a particular regulatory alternative. Net benefits may be positive (negative) indicating that benefits are greater (less) than the costs. Additionally, net benefits may be zero if benefits and costs are equal or if there are no benefits and costs associated with a regulatory action. When net benefits are greater than zero, a regulatory alternative is considered to be net beneficial. However, as was noted earlier, the results of the analysis must be treated with great care.

Net benefits are calculated by subtracting total costs from total benefits. As a result, this calculation requires that benefits and costs are represented in commeasurable units. Therefore, benefits which are measured in fatalities and non-fatal injuries must be translated into monetary value.

Table 53 presents the calculation of monetized benefits. Monetized benefits are calculated by multiplying the number of non-fatal injuries and fatalities prevented by their corresponding comprehensive costs.[29] Monetized benefits for passenger cars and LTVs are estimated at approximately $317.0 million and $473.4 million, respectively.

[29] See Appendix C: Comprehensive Costs.

Table 53: Calculation of Monetized Benefits

MAIS Level	Passenger Cars			LTVs		
	Benefits	**Comprehensive Cost**	**Monetized Benefits**	**Benefits**	**Comprehensive Cost**	**Monetized Benefits**
MAIS 1	-23.3	$44,752	-$1,044,347	-47.2	$44,752	-$2,110,549
MAIS 2	-3.7	$541,175	-$1,998,442	1.2	$541,175	$648,910
MAIS 3	7.0	$1,286,349	$9,065,307	16.8	$1,286,349	$21,634,918
MAIS 4	-0.7	$3,194,328	-$2,281,964	-0.3	$3,194,328	-$1,113,708
MAIS 5	-2.5	$7,307,122	-$18,209,484	-2.6	$7,307,122	-$18,879,576
Fatal	27.8	$11,930,276	$331,498,125	39.7	$11,930,276	$473,180,241
Total			**$317,029,196**			**$473,360,235**

Note: Values may not sum due to rounding.

Table 54 presents the discounted monetized benefits associated with the proposed rule. When discounted at three and seven percent, monetized benefits are approximately $653.8 million and $529.7 million, respectively.

Table 54: Discounted Monetized Benefits (Millions)

Category	Discounted at 3%			Discounted at 7%		
	Monetized Benefits	Adjustment Factor	Discounted Monetized Benefits	Monetized Benefits	Adjustment Factor	Discounted Monetized Benefits
PCs	$317.03	0.8354	$264.85	$317.03	0.6816	$216.09
LTVs	$473.36	0.8216	$388.91	$473.36	0.6626	$313.65
Total			**$653.76**			**$529.74**

Note: Values may not sum due to rounding.

Table 55 displays the net benefits associated with the proposed rule. When discounted at three and seven percent, net benefits are approximately $593.3 million and $480.8 million, respectively. Net benefits greater than zero for both discount rates indicate that the proposed rule is net beneficial.

Table 55: Summary of Net Benefits (Millions)

Discount Rate	Monetized Benefits	Total Cost	Net Benefits
3%	$653.76	$60.43	$593.33
7%	$529.74	$48.94	$480.79

Note: Values may not sum due to rounding.

7.3. Summary

This chapter presented the cost-effectiveness and benefit-cost analyses for the proposed rule. Benefits associated with the proposed rule, which are measured in fatalities and non-fatal injuries prevented, were converted into equivalent lives saved. When discounted at both three and seven percent, the cost per equivalent life saved is approximately $1.10 million for the proposed alternative.

To calculate net benefits, both benefits and costs must be represented in commeasurable units.

Therefore, benefits are translated into monetary value. When discounted at three and seven percent, net benefits associated with the proposed rule are approximately $593.3 million and $480.8 million, respectively. Therefore, the proposed rule is considered to be net beneficial.

8. Sensitivity and Probabilistic Uncertainty Analyses

This chapter presents the sensitivity and uncertainty analyses for the proposed rule. The first section presents the sensitivity analysis that demonstrates how benefits and costs may change based on the assumptions used in the analysis. The following section then presents the probabilistic uncertainty analysis that identifies and quantifies the major uncertainties in the cost-effectiveness and net benefit (benefit-cost) analyses.

8.1. Sensitivity Analysis

This section presents the sensitivity analysis. A sensitivity analysis considers how different assumptions used in the analysis may impact the overall conclusions. This sensitivity analysis examines the impact of various VSLs on the findings of cost-effectiveness and net benefits analyses for the proposed rule. More specifically, this analysis considers a VSL that is 40 percent higher and lower than the primary VSL.

Table 56 presents the comprehensive unit costs for the higher and lower VSLs considered in this sensitivity analysis. Taking into account a 40 percent decrease in the VSL, the lower VSL employed in this analysis is approximately $7.16 million. Taking into account a 40 percent increase in the VSL, the higher VSL employed in this analysis is approximately $16.70 million. The following subsections present net benefits making use of the comprehensive costs associated with the lower and higher VSL.

Table 56: Comprehensive Unit Costs by Two Alternative VSLs

Injury Severity	Primary VSL	Lower VSL	Higher VSL
MAIS 1	$44,752	$26,851	$62,653
MAIS 2	$541,175	$324,705	$757,645
MAIS 3	$1,286,349	$771,809	$1,800,889
MAIS 4	$3,194,328	$1,916,597	$4,472,059
MAIS 5	$7,307,122	$4,384,273	$10,229,971
Fatality	$11,930,276	$7,158,166	$16,702,386

Note: Values may not sum due to rounding. For presentation purposes, comprehensive unit costs for the lower and higher VSL were rounded to the nearest whole dollar.

8.1.1. VSL Value

This subsection presents benefit-cost analysis taking into account both the lower and higher VSL value. For the benefit-cost analysis, the VSL impacts the calculation of monetized benefits and subsequent calculation of net benefits. Table 57 presents the comprehensive unit cost for the lower VSL. Taking into account a 40 percent decrease in the VSL, the lower VSL employed in this analysis is approximately $7.16 million.

Table 57 presents the calculation of monetized benefits for the lower VSL value. Under the lower VSL value, monetized benefits for passenger cars and LTVs are approximately $190.2 million and $284.0 million, respectively.

Table 57: Calculation of Monetized Benefits with Lower VSL

MAIS Level	Passenger Cars			LTVs		
	Benefits	**Comprehensive Cost**	**Monetized Benefits**	**Benefits**	**Comprehensive Cost**	**Monetized Benefits**
MAIS 1	-23.3	$26,851	-$626,608	-47.2	$26,851	-$1,266,329
MAIS 2	-3.7	$324,705	-$1,199,065	1.2	$324,705	$389,346
MAIS 3	7.0	$771,809	$5,439,184	16.8	$771,809	$12,980,951
MAIS 4	-0.7	$1,916,597	-$1,369,178	-0.3	$1,916,597	-$668,225
MAIS 5	-2.5	$4,384,273	-$10,925,690	-2.6	$4,384,273	-$11,327,746
Fatal	27.8	$7,158,166	$198,898,875	39.7	$7,158,166	$283,908,145
Total			**$190,217,518**			**$284,016,141**

Note: Values may not sum due to rounding.

Table 58 presents the discounted monetized benefits associated with the proposed rule for the lower VSL. When discounted at three and seven percent, the monetized benefits are approximately $392.26 million to $317.84, respectively.

Table 58: Discounted Monetized Benefits for Lower VSL (Millions)

Category	Discounted at 3%			Discounted at 7%		
	Monetized Benefits	Adjustment Factor	Discounted Monetized Benefits	Monetized Benefits	Adjustment Factor	Discounted Monetized Benefits
PCs	$190.22	0.8354	$158.91	$190.22	0.6816	$129.65
LTVs	$284.02	0.8216	$233.35	$284.02	0.6626	$188.19
Total			**$392.26**			**$317.84**

Note: Values may not sum due to rounding.

Table 59 displays the net benefits associated with the proposed rule for the lower VSL. When discounted at three and seven percent, the net benefits are approximately $331.8 million and $268.9, respectively. Net benefits greater than zero indicate that the proposed rule is net beneficial even under the lower VSL. Therefore, this sensitivity analysis lends support to the findings in the main analysis which indicated that the proposed rule is net beneficial.

Table 59: Summary of Net Benefits for Lower VSL (Millions)

Discount Rate	Monetized Benefits	Total Cost	Net Benefits
3%	$392.26	$60.43	$331.82
7%	$317.84	$48.94	$268.90

Note: Values may not sum due to rounding.

Taking into account a 40 percent increase in the VSL, the higher VSL employed in this analysis is approximately $16.7 million (see Table 56).

Table 60 presents the calculation of monetized benefits for the higher VLS value. Under the higher VSL value, monetized benefits for passenger cars and LTVs are approximately $443.8 million and $662.7 million, respectively.

Table 60: Calculation of Monetized Benefits with Higher VSL

MAIS Level	Passenger Cars			LTVs		
	Benefits	Comprehensive Cost	Monetized Benefits	Benefits	Comprehensive Cost	Monetized Benefits
MAIS 1	-23.3	$62,653	-$1,462,085	-47.2	$62,653	-$2,954,769
MAIS 2	-3.7	$757,645	-$2,797,819	1.2	$757,645	$908,474
MAIS 3	7.0	$1,800,889	$12,691,430	16.8	$1,800,889	$30,288,885
MAIS 4	-0.7	$4,472,059	-$3,194,749	-0.3	$4,472,059	-$1,559,192
MAIS 5	-2.5	$10,229,971	-$25,493,277	-2.6	$10,229,971	-$26,431,407
Fatal	27.8	$16,702,386	$464,097,376	39.7	$16,702,386	$662,452,337
Total			**$443,840,875**			**$662,704,328**

Note: Values may not sum due to rounding.

Table 61 presents the discounted monetized benefits associated with the proposed rule for the higher VSL. When discounted at three and seven percent, the monetized benefits are $915.3 million and $741.6 million, respectively.

Table 61: Discounted Monetized Benefits for Higher VSL (Millions)

Category	Discounted at 3%			Discounted at 7%		
	Monetized Benefits	**Adjustment Factor**	**Discounted Monetized Benefits**	**Monetized Benefits**	**Adjustment Factor**	**Discounted Monetized Benefits**
PCs	$443.84	0.8354	$370.78	$443.84	0.6816	$302.52
LTVs	$662.70	0.8216	$554.48	$662.70	0.6626	$439.11
Total			**$915.26**			**$741.63**

Note: Values may not sum due to rounding.

Table 62 displays the net benefits associated with the proposed rule for the lower VSL. When discounted at three and seven percent, the net benefits are $854.8 million and $692.7 million, respectively. Net benefits greater than zero indicate that the proposed rule is net beneficial even under the higher VSL. Therefore, this sensitivity analysis lends support to the findings in the main analysis which indicated that the proposed rule is net beneficial.

Table 62: Summary of Net Benefits for Higher VSL (Millions)

Discount Rate	Monetized Benefits	Total Cost	Net Benefits
3%	$915.26	$60.43	$854.83
7%	$741.63	$48.94	$692.69

Note: Values may not sum due to rounding.

8.1.2. Head Injuries as MAIS

This subsection presents the benefit-cost analysis taking into account alternative values for the adjustment to the target population to account for head injuries as MAIS. In section 3.3, the target population is adjusted to reflect only cases in which head injuries were the MAIS (at least one of the maximum AIS injuries to the pedestrian was a head injury from a head-to-hood impact). The analysis made use of the PCDS to estimate what proportion of pedestrian fatalities and injuries are associated with head injuries from impacts to vehicle structures subject to the test procedures in the proposed rule. As the PCDS study was published in 1996, this sensitivity analysis considers alternative values to those from the PCDS. More specifically, this sensitivity analysis considers two hypothetical cases that represent two extremes. This subsection will present the cost-effectiveness and net benefits measures in the case that those values were both halved and doubled. The purpose of this sensitivity analysis is to reflect the possibility that the distribution of injuries by body region could have potentially changed since the PCDS was published due to changes in composition of the fleet.

Table 63 presents the case in which the values reflected in the main analysis from the PCDS (see Table 15) are halved. In this case, pedestrian head injuries attributed to an impact with a structure in the Hood Top area were coded as the most serious or tied for most serious injury in the case (i.e., Head Injury AIS = Case MAIS) in eight percent of fatal passenger car to pedestrian crashes. In 2.1 percent of MAIS 1 or minor injury pedestrian cases and 3.2 percent of MAIS 2 to MAIS 5 pedestrian cases, a head injury of severity equal to the case MAIS was attributed to an impact to the Hood Top area of the passenger car. Similarly, in 7.4 percent of fatal LTV to pedestrian crashes, pedestrian head injuries attributed to an impact with a structure in the Hood Top area were coded as the most serious or tied for most serious injury in the case. In 1.4 percent of those MAIS 1 pedestrian injury cases and 4.3 percent of MAIS 2 to MAIS 5 pedestrian injury cases, a head injury of severity equal to the case MAIS was attributed to an impact to the Hood Top area of the LTV.

Table 63: Sensitivity Analysis: Percent Head Injury as MAIS when Halved

Injury Severity	Passenger Cars	LTVs
MAIS 1	2.1%	1.4%
MAIS 2-MAIS 5	3.2%	4.3%
Fatal	8.0%	7.4%

Table 64 presents the total annual incremental benefits when the percentage of head injuries as MAIS in the main analysis is halved. As all other adjustments to the target population and effectiveness estimates remain unchanged in this sensitivity analysis, the benefits estimated under this sensitivity analysis are exactly half of those estimated in the main analysis. Under the assumptions of this sensitivity analysis, a total of approximately 33.7 fatalities would be mitigated annually as a result of the proposed rule.

Table 64: Total Annual Incremental Benefits: Percent Head Injury as MAIS Halved

Injury Severity	Benefits by Vehicle Type		Total Benefits
	Passenger Cars	LTVs	
MAIS 1	-11.7	-23.6	-35.2
MAIS 2	-1.8	0.6	-1.2
MAIS 3	3.5	8.4	11.9
MAIS 4	-0.4	-0.2	-0.5
MAIS 5	-1.2	-1.3	-2.5
Fatalities	13.9	19.8	33.7

Note: Values may not sum due to rounding. Negative values represent an increase in the number of injuries at that specific severity.

Table 65 presents the findings of the benefit-cost analysis when the percentage of head injuries as MAIS in the main analysis is halved. When discounted at three and seven percent, monetized benefits for this sensitivity analysis are approximately $326.88 million and $264.87 million, respectively. Furthermore, net benefits range from approximately $215.93 million to $266.45 million indicating that the proposed rule remains net beneficial when the percent head injury as MAIS are halved.

Table 65: Net Benefits: Percent Head Injury as MAIS Halved (Millions)

Discount Rate	Monetized Benefits	Total Cost	Net Benefits
3%	$326.88	$60.43	$266.45
7%	$264.87	$48.94	$215.93

Note: Values may not sum due to rounding.

Table 66 presents the case in which the values reflected in the main analysis from the PCDS (see Table 15) are doubled. In this case, pedestrian head injuries attributed to an impact with a structure in the Hood Top area were coded as the most serious or tied for most serious injury in the case (i.e., Head Injury AIS = Case MAIS) in 31.8 percent of fatal passenger car to pedestrian crashes. In 8.4 percent of MAIS 1 or minor injury pedestrian cases and 12.6 percent of MAIS 2 to MAIS 5 pedestrian cases, a head injury of severity equal to the case MAIS was attributed to an impact to the Hood Top area of the passenger car. Similarly, in 29.6 percent of fatal LTV to pedestrian crashes, pedestrian head injuries attributed to an impact with a structure in the Hood Top area were coded as the most serious or tied for most serious injury in the case. In 5.6 percent of those MAIS 1 pedestrian injury cases and 17.2 percent of MAIS 2 to MAIS 5 pedestrian injury cases, a head injury of severity equal to the case MAIS was attributed to an impact to the Hood Top area of the LTV.

Table 66: Sensitvity Analysis: Percent Head Injury as MAIS when Doubled

Injury Severity	Passenger Cars	LTVs
MAIS 1	8.4%	5.6%
MAIS 2-MAIS 5	12.6%	17.2%
Fatal	31.8%	29.6%

Table 67 presents the total annual incremental benefits when the percentage of head injuries as MAIS in the main analysis is doubled. As all other adjustments to the target population and effectiveness estimates remain unchanged in this sensitivity analysis, the benefits estimated under this sensitivity analysis are exactly double of those estimated in the main analysis. Under the assumptions of this sensitivity analysis, a total of approximately 134.9 fatalities are mitigated annual as a result of the proposed rule.

Table 67: Total Annual Incremental Benefits: Percent Head Injury as MAIS Doubled

Injury Severity	Benefits by Vehicle Type		Total Benefits
	Passenger Cars	LTVs	
MAIS 1	-46.7	-94.3	-141.0
MAIS 2	-7.4	2.4	-5.0
MAIS 3	14.1	33.6	47.7
MAIS 4	-1.4	-0.7	-2.1
MAIS 5	-5.0	-5.2	-10.2
Fatalities	55.6	79.3	134.9

Note: Values may not sum due to rounding. Negative values represent an increase in the number of injuries at that specific severity.

Table 68 presents the findings of the benefit-cost analysis when the percentage of head injuries as MAIS in the main analysis is doubled. When discounted at three and seven percent, monetized benefits for this sensitivity analysis are approximately $1.31 billion and $1.06 billion, respectively. Furthermore, net benefits range from approximately $1.25 billion to $1.01 billion indicating that the proposed rule remains net beneficial when the percent head injury as MAIS are doubled.

Table 68: Net Benefits: Percent Head Injury as MAIS Doubled (Millions)

Discount Rate	Monetized Benefits	Total Cost	Net Benefits
3%	$1,307.52	$60.43	$1,247.09
7%	$1,059.47	$48.94	$1,010.53

Note: Values may not sum due to rounding.

8.1.3. Fuel Economy Impacts: Fleet Composition

This subsection presents the benefit-cost analysis taking into account alternative assumptions for the cost analysis. The cost analysis presented in Chapter 5 considers the impact of one additional pound of weight on the fuel economy cost throughout the lifetime of passenger cars and LTVs. As there is a trend toward larger vehicles, this analysis considers the hypothetical case in which all of the vehicles subject to the proposed rule were LTVs.

Table 69 presents the total annual cost when taking into account the fuel economy impacts for LTVs for all vehicles subject to the proposed rule. This analysis takes into account the discounted lifetime fuel economy costs for LTVs (see Table 47) and applies to all light vehicles. When discounted at three and seven percent, the total cost under the assumptions of this sensitivity analysis are approximately $64.02 million and $51.63 million, respectively.

Table 69: Sensitivity Analysis: Total Annual Cost for LTV Fuel Economy Impacts for All Light Vehicles

Number of Vehicles Impacted	Per Vehicle Cost		Total Cost	
	Discounted at 3%	Discounted at 7%	Discounted at 3%	Discounted at 7%
15,701,000	$4.08	$3.29	$64.02	$51.63

Note: Values may not sum due to rounding.

Table 70 presents the findings of the benefit-cost analysis taking into account the fuel economy impacts for LTVs for all vehicles subject to the proposed rule. When discounted at three and seven percent, net benefits under the assumptions of this sensitivity analysis range from approximately $589.74 million to $478.11 million indicating that the proposed rule remains net beneficial even when reflecting the fuel economy costs for LTVs on all vehicles subject to the proposed rule.

Table 70: Net Benefits: LTV Fuel Economy Impacts for All Light Vehicles

Discount Rate	Monetized Benefits	Total Cost	Net Benefits
3%	$653.76	$64.02	$589.74
7%	$529.74	$51.63	$478.11

Note: Values may not sum due to rounding.

8.2. Probabilistic Uncertainty Analysis

This section identifies and quantifies the major uncertainty in the cost-effectiveness and net benefit (benefit-cost) analyses. The key assumptions for both the cost-effectiveness and net benefit analyses center on factors influencing benefits: the VSL and the target population. Uncertainty in benefits-related assumptions is associated with uncertainty in the estimated regulatory outcomes. An uncertainty analysis is generally conducted to identify the combined effect of uncertainty factors with meaningful variability; uncertainty is represented in these analyses through the use of assumed probability distributions. Typically, as in this analysis, values from these distributions are randomly selected and fed back to the cost-effectiveness and net benefit analyses process using Monte Carlo statistical simulation (e.g., Robert and Casella, 2001).

In this case, the uncertainty analysis starts by describing how variability in benefits driven by the VSL and target population jointly affects cost-effectiveness and net benefits estimates within the Monte Carlo simulation. Variability among uncertainty factors is described by probability distribution functions informed by data, to the extent that sufficient data are available. If data are not sufficient or not available, professional judgments are used to estimate the distributions of these uncertainty factors. To represent uncertainty in benefits meaningfully, our assumed ranges for the VSL and target population are bounded by the lower and higher assumptions in the sensitivity analysis. We selected triangular distributions (with mode equal to the center of the range), because this enables random draws from distributions that: (1) place a higher weight on values near our central values; and (2) are symmetrical. Overall benefits were projected within the uncertainty analysis by simulating the ratio of the VSL to our central VSL (i.e., factors ranging from 0.6 to 1.4) and then multiplying that ratio by a simulated value of the safety impact when allowing the target population to vary while holding the VSL at its central value.

We also carried forward the information from the sensitivity analysis regarding costs forward, by simulating outcomes across a uniform distribution with a lower bound equal to the central value and an upper bound equal to the sensitivity value representing higher incremental fuel costs. A uniform distribution was chosen to allow for a maximum impact of potential higher costs relative to the central analysis.

The Monte Carlo simulation was conducted using Oracle Crystal Ball within Microsoft Excel. The simulation generated 10,000 outcomes, each of which includes one random draw from each of the VSL distribution and target population distribution described directly above. Subtracting the simulated cost estimate from the simulated outcome for benefits yields a distribution of net benefits, presented in Figure 7 and Figure 8 at three percent and seven percent discount rates, respectively.

Figure 7: Frequency Distribution for Net Benefits (Millions of Dollars, 3% Discount Rate, 10,000 Random Draws, 95% Confidence Interval Included)

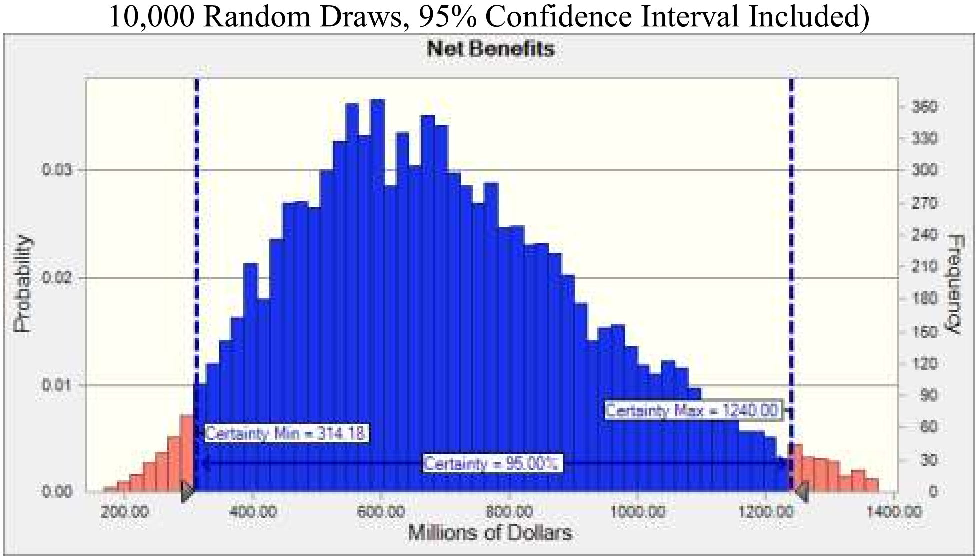
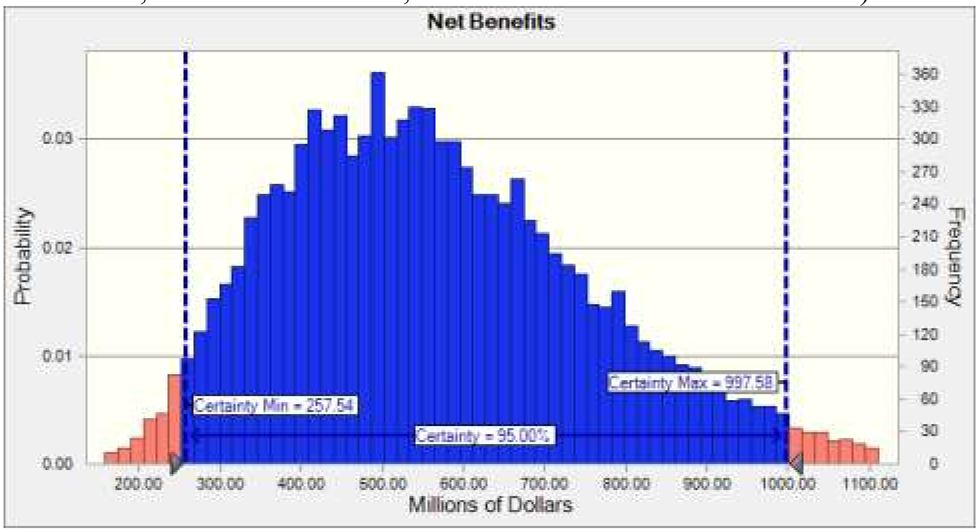


Figure 8: Frequency Distribution for Net Benefits (Millions of Dollars, 7% Discount Rate, 10,000 Random Draws, 95% Confidence Interval Included)



The Monte Carlo simulation yielded results consistent with the specified input distributions. The projected mean and median net benefits were somewhat larger than in the central analysis (when discounted at three percent, $703 million for the mean and $676 million for the median versus $593 million in the central analysis; when discounted at seven percent, mean of $568 million and median of $545 million versus $481 million in the central analysis). The discrepancy between the central analysis and the mean and median values in the uncertainty analysis reflects the asymmetrical effects of uncertainty in the target population. The estimated 95-percent confidence bounds for net benefits are $314 million to $1.24 billion when discounted at three percent ($258 million to $998 million when discounted at seven percent). In all cases, projected net benefits are positive (minima of $170 million when discounted at three percent and $159 million when discounted at seven percent).

Equivalent lives saved represents an alternative representation of benefits, and hence follows the identical distribution as benefits. Dividing simulated costs by simulated equivalent lives saved yields a distribution of simulated costs per equivalent life saved that is skewed toward the upper tail , as shown in Figure 9 and Figure 10.

Figure 9: Frequency Distribution for Cost per Equivalent Life Saved (Dollars, 3% Discount Rate, 10,000 Random Draws, 95% Confidence Interval Included)

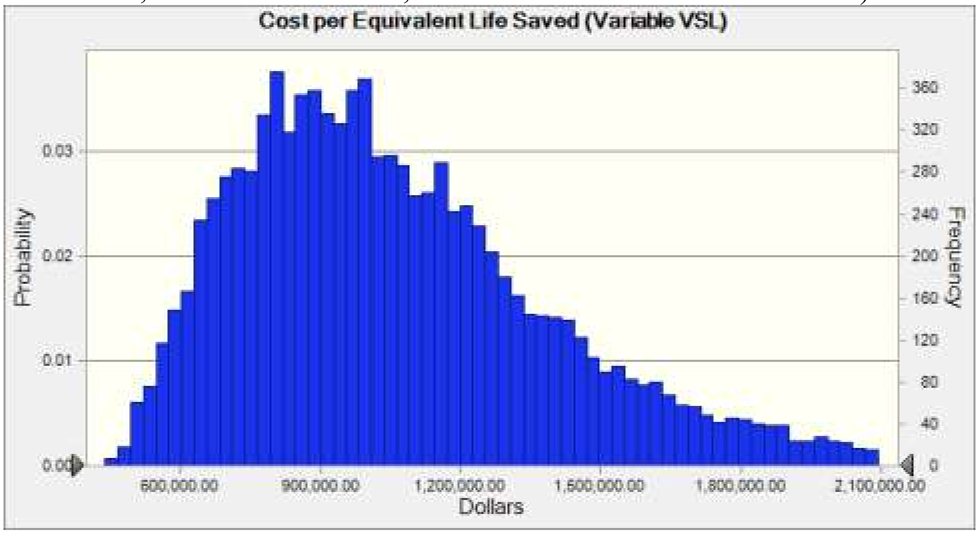
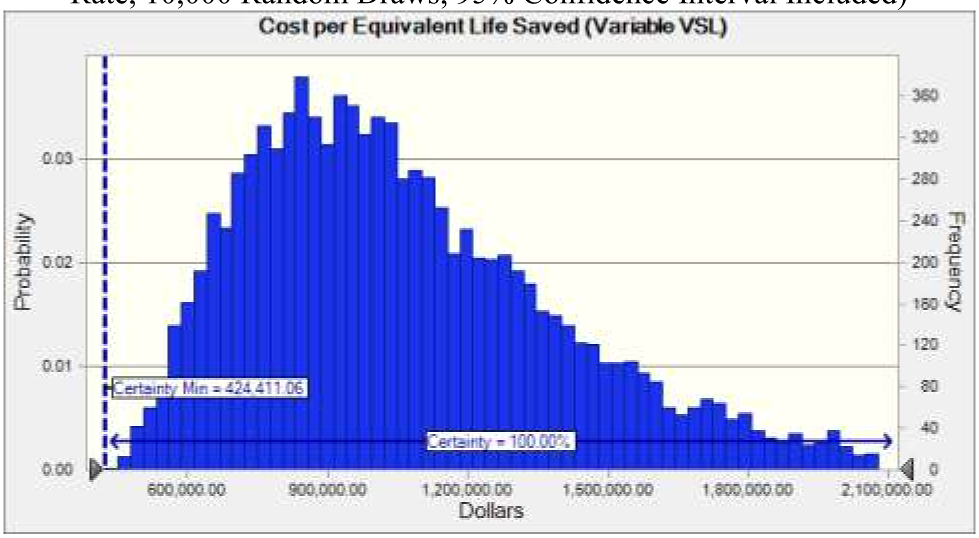


Figure 10: Frequency Distribution for Cost per Equivalent Life Saved (Dollars, 7% Discount Rate, 10,000 Random Draws, 95% Confidence Interval Included)



Mean and median cost per equivalent life saved in the Monte Carlo simulation are consistent with the central analysis. The mean and median are $1.07 million and $1.00 million, respectively at both three percent and seven percent discount rates, versus $1.10 million at a three percent discount rate in the central analysis ($1.14 million at a seven percent discount rate). The estimated 95 percent confidence bounds are $0.57 million to $1.97 million when discounted at three percent ($0.57 million to $1.95 million when discounted at seven percent). In all cases, projected cost per equivalent life saved is well below the VSL (maxima of $3.24 million and $2.84 million when discounted at three and seven percent, respectively).

9. Regulatory Alternatives

This chapter presents the regulatory alternatives considered by the agency, as well as the cost-effectiveness and benefit-cost analyses for those regulatory options. Table 71 provides a summary of the regulatory alternatives considered for this rulemaking. The following sections discuss the regulatory alternatives, as well as any benefit and cost considered. The last section in this chapter presents a comparison on the regulatory alternatives considered for this rulemaking.

Table 71: Summary of Regulatory Alternatives

Regulatory Alternative	**Requirement**	**Test Area**	**HIC1000 Area**	**HIC1700 Area**
#1	Less Stringent	Requirements that match the EU interpretation of GTR 9 (GTR 9 Amendment 3)	2/3 of Test Area	1/3 of Test Area
#2	Preferred Option	Proposed Rule	2/3 of Hood Area, confined to Test Area	Remaining Test Area
#3	More Stringent	Requirements applicable to the entire hood instead of just the Test Area.	2/3 of Hood Top	1/3 of Hood Top

9.1. Regulatory Alternative #1

This regulatory alternative considers the less stringent condition in which the requirements specified in the proposed rule would match the EU interpretation of GTR 9 (GTR 9 Amendment 3).[30] Under this regulatory alternative the "Hood Area" is enclosed by the side reference lines, WAD 1000 or BLE at the front, whichever is more rearward, and WAD 2100 or RRL at the rear,

[30] An amendment to GTR 9 submitted for by the Economic Commission of Europe in 2021. Amendment 3 can be found at TWSG-01-04 - ECE-TRANS-WP29-2021-053e, https://unece.org/sites/default/files/2021-02/ECE-TRANS-WP29-2021-053e.pdf. See the FMVSS No. 228 NPRM for additional details related to this amendment.

whichever is more forward. Furthermore, the “Test Area” is enclosed by the 82.5 mm inside the side reference lines, WAD 1000 or 82.5 mm rear of BLE at the front, whichever is more rearward, and WAD 2100 or 82.5 mm forward of RRL at the rear, whichever is more forward.[31] The main difference between alternative #1 and the proposed rule is the allowable HIC1000 area. As stated previously, the proposed standard specifies that the HIC1000 area must be at least two-thirds of the Hood Area, confined to the Test Area. Furthermore, the proposed standard specifies that only the remaining Test Area is limited to HIC1700. By contrast, for alternative #1 the HIC 1000 area is two-thirds of the Test Area and the HIC1700 area is one-third of the Test Area. Thus, alternative #1 allows for greater area with a less stringent HIC1700 requirement. The following subsections present the target population, benefits, costs, and cost-effectiveness and benefit cost analyses for this regulatory alternative.

9.1.1. Target Population

This subsection presents the target population for regulatory alternative #1. Table 72 and Table 73 preset the target population for regulatory alternative #1 for passenger cars and LTVs, respectively. Note that the target population for this regulatory alternative is the same as the target population in the main analysis including all of the adjustments for PAEB benefits, head injuries as MAIS, Test Area, and impact speed.

[31] United Nations Economic Commission for Europe, Transport: Vehicle Regulations; 1998 Agreement on Global Technical Regulations, Appendix to Global Technical Regulation No. 9 Pedestrian Safety (ECE/TRANS/180/Add.9/Appendix 1), Geneva, Switzerland, 2009.

Table 72: Regulatory Alternative #1: Target Population for Passenger Cars

Injury Severity	Speed Limit (mph/km/h)				TOTAL
	<25	30	35	40+	
	<40	48	56	64+	
MAIS 1	250	92	171	197	710
MAIS 2	94	32	66	55	248
MAIS 3	45	15	34	29	123
MAIS 4	4	1	1	0	7
MAIS 5	2	1	1	0	4
Fatalities	26	14	19	16	75

Note: Fatalities and non-fatal injuries are rounded to the nearest whole number for presentation purposes.

Table 73: Regulatory Alternative #1: Target Population for LTVs

Injury Severity	Speed Limit (mph/km/h)				TOTAL
	<25	30	35	40+	
	<40	48	56	64+	
MAIS 1	168	53	112	120	454
MAIS 2	125	39	84	68	317
MAIS 3	58	18	41	35	152
MAIS 4	5	1	2	0	8
MAIS 5	3	1	1	0	5
Fatalities	36	17	22	17	92

Note: Fatalities and non-fatal injuries are rounded to the nearest whole number for presentation purposes.

9.1.2. Benefits

This subsection presents the calculation of benefits for regulatory alternative #1, based on the test results in Appendix G. The probability of injury in the tests was estimated for passenger cars under the condition that the vehicles would be compliant with regulatory alternative #1 (Table 151).

Table 74 presents the percentage change in the probability of fatal and non-fatal injuries for regulatory alternative #1 for passenger cars compared to the probability estimated for the baseline fleet tests. Overall, we find that regulatory alternative #1 is approximately 30.0 percent effective in mitigating fatalities for passenger cars.[32]

[32] Calculations in Appendix G: Calculations for Regulatory Alternatives.

Table 74: Regulatory Alternative #1: Percentage Change in the Probability of Fatal and Non-Fatal Injuries for Passenger Cars

Injury Severity	**Percentage Change in Probability**
MAIS 1+F	0.3%
MAIS 2+F	4.5%
MAIS 3+F	11.6%
MAIS 4+F	22.7%
MAIS 5+F	25.6%
Fatalities	30.0%

Table 75 and Table 76 present the change in MAIS+F injuries for passenger cars under regulatory alternative #1. For presentation purposes, these two tables are split. Table 75 presents the portion of the change in MAIS+F injuries represented by MAIS 1+F to MAIS 3+F and Table 76 presents the portion of the change in MAIS+F injuries represent by MAIS 4+F to fatalities. The change in MAIS+F injuries is calculated by reflecting the percentage change in the probability of fatal and non-fatal injuries associated with this regulatory alternative (Table 74) on the MAIS+F injuries in the target population.

Table 75: Regulatory Alternative #1: Change in MAIS+F Injuries for Passenger Cars (MAIS 1+F to MAIS 3+F)

Injury Severity		MAIS 1+F			MAIS 2+F			MAIS 3+F		
Speed Limit (mph/km/h)		TP (Baseline)	% Reduction	Proposed Rule	TP (Baseline)	% Reduction	Proposed Rule	TP (Baseline)	% Reduction	Proposed Rule
<25	**<40**	421.7	0.3%	420.6	171.8	4.5%	164.1	77.5	11.6%	68.5
30	**48**	154.4	0.3%	154.0	62.8	4.5%	59.9	30.6	11.6%	27.1
35	**56**	292.6	0.3%	291.8	121.3	4.5%	115.9	55.5	11.6%	49.1
40+	**64+**	297.6	0.3%	296.8	100.5	4.5%	96.0	45.2	11.6%	40.0
Total		**1,166.3**	**-**	**1,163.1**	**456.5**	**-**	**436.0**	**208.9**	**-**	**184.7**

Note: Values may not sum due to rounding.

Table 76: Regulatory Alternative #1: Change in MAIS+F Injuries for Passenger Cars (MAIS 4+F to Fatality)

Injury Severity		MAIS 4+F			MAIS 5+F			Fatalities		
Speed Limit (mph/km/h)		TP (Baseline)	% Reduction	Proposed Rule	TP (Baseline)	% Reduction	Proposed Rule	TP (Baseline)	% Reduction	Proposed Rule
<25	**<40**	32.2	22.7%	24.9	28.0	25.6%	20.8	25.6	30.0%	17.9
30	**48**	15.9	22.7%	12.3	15.0	25.6%	11.2	14.5	30.0%	10.1
35	**56**	21.8	22.7%	16.8	20.4	25.6%	15.1	19.4	30.0%	13.6
40+	**64+**	16.3	22.7%	12.6	15.8	25.6%	11.8	15.6	30.0%	10.9
Total		**86.1**	**-**	**66.6**	**79.2**	**-**	**58.9**	**75.1**	**-**	**52.6**

Note: Values may not sum due to rounding.

Table 77 and Table 78 present the calculation of MAIS injuries resulting from passenger cars striking pedestrians under the baseline for regulatory alternative #1. MAIS injuries can be calculated by subtracting the number of MAIS+F one level above from the MAIS+F injuries. For example, to calculate MAIS 1 injuries, we would subtract MAIS 2+F from the MAIS 1+F total.

Table 77: Baseline MAIS for Passenger Cars (MAIS 1 to MAIS 3)

Injury Severity		MAIS 1		MAIS 2		MAIS 3	
Speed Limit (mph/km/h)		**Calculation Based on MAIS+F**	**MAIS Total**	**Calculation Based on MAIS+F**	**MAIS Total**	**Calculation Based on MAIS+F**	**MAIS Total**
<25	**<40**	421.7 – 171.8	249.9	171.8 – 77.5	94.3	77.5 – 32.2	45.4
30	**48**	154.4 – 62.8	91.6	62.8 – 30.6	32.1	30.6 – 15.9	14.7
35	**56**	292.6 – 121.3	171.2	121.3 – 55.5	65.8	55.5 – 21.8	33.7
40+	**64+**	297.6 – 100.5	197.0	100.5 – 45.2	55.3	45.2 – 16.3	28.9
Total		-	**709.8**	-	**247.6**	-	**122.8**

Note: Values may not sum due to rounding.

Table 78: Baseline MAIS for Passenger Cars (MAIS 4 to Fatalities)

Injury Severity		MAIS 4		MAIS 5		Fatality	
Speed Limit (mph/km/h)		**Calculation Based on MAIS+F**	**MAIS Total**	**Calculation Based on MAIS+F**	**MAIS Total**	**Calculation Based on MAIS+F**	**MAIS Total**
<25	**<40**	32.2 – 28.0	4.1	28.0 – 25.6	2.4	-	25.6
30	**48**	15.9 – 15.0	0.9	15.0 – 14.5	0.5	-	14.5
35	**56**	21.8 – 20.4	1.4	20.4 – 19.4	0.9	-	19.4
40+	**64+**	16.3 – 15.8	0.4	15.8 – 15.6	0.3	-	15.6
Total		-	**6.9**	-	**4.1**	-	**75.1**

Note: Values may not sum due to rounding.

Table 79 and Table 80 present the calculation of MAIS injuries resulting from passenger cars striking pedestrians for regulatory alternative #1. MAIS injuries can be calculated by subtracting the number of MAIS+F one level above from the MAIS+F injuries. For example, to calculate MAIS 1 injuries, we would subtract MAIS 2+F from the MAIS 1+F total.

Table 79: Regulatory Alternative #1: MAIS for Passenger Cars (MAIS 1 to MAIS 3)

Injury Severity		MAIS 1		MAIS 2		MAIS 3	
Speed Limit (mph/km/h)		Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total
<25	<40	420.6 – 164.1	256.5	164.1 – 68.5	95.6	68.5 – 24.9	43.7
30	48	154.0 – 59.9	94.0	59.9 – 27.1	32.8	27.1 – 12.3	14.8
35	56	291.8 – 115.9	175.9	115.9 – 49.1	66.8	49.1 – 16.8	32.2
40+	64+	296.8 – 96.0	200.7	96.0 – 40.0	56.1	40.0 – 12.6	27.4
Total		**-**	**727.2**	**-**	**251.3**	**-**	**118.0**

Note: Values may not sum due to rounding.

Table 80: Regulatory Alternative #1: MAIS for Passenger Cars (MAIS 4 to Fatalities)

Injury Severity		MAIS 4		MAIS 5		Fatality	
Speed Limit (mph/km/h)		Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total
<25	<40	24.9 – 20.8	4.0	20.8 – 17.9	2.9	-	17.9
30	48	12.3 – 11.2	1.1	11.2 – 10.1	1.0	-	10.1
35	56	16.8 – 15.1	1.7	15.1 – 13.6	1.5	-	13.6
40+	64+	12.6 – 11.8	0.8	11.8 – 10.9	0.9	-	10.9
Total		**-**	**7.7**	**-**	**6.4**	**-**	**52.6**

Note: Values may not sum due to rounding.

Table 81 and Table 82 present the total incremental benefits for passenger cars for regulatory alternative #1. Incremental benefits are the difference in MAIS injuries between the baseline and the regulatory alternative. As a result of the regulatory alternative #1, a total of approximately 22.6 fatalities resulting from cases in which a passenger car strikes a pedestrian would be mitigated. Note that the countermeasures to meet the requirements specified in the proposed rule mitigate fatalities which become less severe non-fatal injuries and mitigate more severe non-fatal injuries which become less severe injuries. Although the net total of non-fatal injuries from MAIS1 to MAIS 5 increase under the proposed rule due to the trickle-down of those fatalities and non-fatal injuries, overall there is a benefit at each MAIS level.

Table 81: Regulatory Alternative #1: Total Annual Incremental Benefits for Passenger Cars (MAIS 1 to MAIS 3)

Injury Severity		MAIS 1			MAIS 2			MAIS 3		
Speed Limit (mph/km/h)		Baseline	Regulatory Alternative #1	Benefits	Baseline	Regulatory Alternative #1	Benefits	Baseline	Regulatory Alternative #1	Benefits
<25	<40	249.9	256.5	-6.6	94.3	95.6	-1.3	45.4	43.7	1.7
30	48	91.6	94.0	-2.4	32.1	32.8	-0.7	14.7	14.8	-0.1
35	56	171.2	175.9	-4.7	65.8	66.8	-1.0	33.7	32.2	1.5
40+	64+	197.0	200.7	-3.7	55.3	56.1	-0.7	28.9	27.4	1.6
Total		**709.8**	**727.2**	**-17.4**	**247.6**	**251.3**	**-3.8**	**122.8**	**118.0**	**4.7**

Note: Values may not sum due to rounding.

Table 82: Regulatory Alternative #1:Total Annual Incremental Benefits for Passenger Cars (MAIS 4 to Fatalities)

Injury Severity		MAIS 4			MAIS 5			Fatality		
Speed Limit (mph/km/h)		Baseline	Regulatory Alternative #1	Benefits	Baseline	Regulatory Alternative #1	Benefits	Baseline	Regulatory Alternative #1	Benefits
<25	<40	4.1	4.0	0.1	2.4	2.9	-0.5	25.6	17.9	7.7
30	48	0.9	1.1	-0.2	0.5	1.0	-0.5	14.5	10.1	4.4
35	56	1.4	1.7	-0.3	0.9	1.5	-0.6	19.4	13.6	5.8
40+	64+	0.4	0.8	-0.4	0.3	0.9	-0.6	15.6	10.9	4.7
Total		**6.9**	**7.7**	**-0.8**	**4.1**	**6.4**	**-2.3**	**75.1**	**52.6**	**22.6**

Note: Values may not sum due to rounding.

Table 83 presents the percentage change in the probability of fatal and non-fatal injuries for regulatory alternative #1 for LTVs. Overall, we find that regulatory alternative #1 is approximately 19.0 percent effective in mitigating fatalities for LTVs.[33]

Table 83: Regulatory Alternative #1: Percentage Change in the Probability of Fatal and Non-Fatal Injuries for LTVs

Injury Severity	**Percentage Change in Probability**
MAIS 1+F	0.3%
MAIS 2+F	4.3%
MAIS 3+F	9.3%
MAIS 4+F	15.5%
MAIS 5+F	16.9%
Fatalities	19.0%

Table 84 and Table 85 present the change in MAIS injuries for LTVs under regulatory alternative #1. The change in MAIS+F injuries is calculated by reflecting the percentage change in the probability of fatal and non-fatal injuries associated with the proposed rule (Table 83) on the MAIS+F injuries in the target population.

[33] Calculations in Appendix G: Calculations for Regulatory Alternatives.

Table 84: Regulatory Alternative #1: Change in MAIS+F Injuries for LTVs (MAIS 1+F to MAIS 3+F)

Injury Severity		MAIS 1+F			MAIS 2+F			MAIS 3+F		
Speed Limit (mph/km/h)		TP (Baseline)	% Reduction	Regulatory Alternative #1	TP (Baseline)	% Reduction	Regulatory Alternative #1	TP (Baseline)	% Reduction	Regulatory Alternative #1
<25	**<40**	395.6	0.3%	394.3	227.3	4.3%	217.5	101.8	9.3%	92.3
30	**48**	129.9	0.3%	129.4	76.8	4.3%	73.5	37.5	9.3%	34.0
35	**56**	261.9	0.3%	261.0	149.7	4.3%	143.3	65.3	9.3%	59.2
40+	**64+**	240.6	0.3%	239.8	120.3	4.3%	115.1	52.5	9.3%	47.6
Total		**1,028.0**	**-**	**1,024.5**	**574.1**	**-**	**549.3**	**257.1**	**-**	**233.2**

Note: Values may not sum due to rounding.

Table 85: Regulatory Alternative #1: Change in MAIS+F Injuries for LTVs (MAIS 3+F to Fatality)

Injury Severity		MAIS 4+F			MAIS 5+F			Fatalities		
Speed Limit (mph/km/h)		TP (Baseline)	% Reduction	Regulatory Alternative #1	TP (Baseline)	% Reduction	Regulatory Alternative #1	TP (Baseline)	% Reduction	Regulatory Alternative #1
<25	**<40**	44.2	15.5%	37.4	39.2	16.9%	32.5	36.4	19.0%	29.4
30	**48**	19.1	15.5%	16.2	18.0	16.9%	14.9	17.3	19.0%	14.0
35	**56**	24.2	15.5%	20.5	22.5	16.9%	18.7	21.5	19.0%	17.4
40+	**64+**	17.8	15.5%	15.0	17.3	16.9%	14.3	17.0	19.0%	13.7
Total		**105.3**	**-**	**89.0**	**97.0**	**-**	**80.6**	**92.2**	**-**	**74.6**

Note: Values may not sum due to rounding.

Table 86 and Table 87 present the calculation of MAIS injuries resulting from passenger cars striking pedestrians under the baseline for this regulatory alternative. MAIS injuries can be calculated by subtracting the number of MAIS+F one level above from the MAIS+F injuries. For example, to calculate MAIS 1 injuries, we would subtract MAIS 2+F from the MAIS 1+F total.

Table 86: Regulatory Alternative #1: Baseline MAIS for LTVs (MAIS 1 to MAIS 3)

Injury Severity		MAIS 1		MAIS 2		MAIS 3	
Speed Limit (mph/km/h)		**Calculation Based on MAIS+F**	**MAIS Total**	**Calculation Based on MAIS+F**	**MAIS Total**	**Calculation Based on MAIS+F**	**MAIS Total**
<25	**<40**	395.6 – 227.3	168.4	227.3 – 101.8	125.5	101.8 – 44.2	57.6
30	**48**	129.9 – 76.8	53.0	76.8 – 37.5	39.3	37.5 – 19.1	18.4
35	**56**	261.9 – 149.7	112.2	149.7 – 65.3	84.4	65.3 – 24.2	41.1
40+	**64+**	240.6 – 120.3	120.3	120.3 – 52.5	67.8	52.5 – 17.8	34.7
Total		-	**453.9**	-	**317.0**	-	**151.7**

Note: Values may not sum due to rounding.

Table 87: Regulatory Alternative #1: Baseline MAIS for LTVs (MAIS 4 to Fatalities)

Injury Severity		MAIS 4		MAIS 5		Fatality	
Speed Limit (mph/km/h)		**Calculation Based on MAIS+F**	**MAIS Total**	**Calculation Based on MAIS+F**	**MAIS Total**	**Calculation Based on MAIS+F**	**MAIS Total**
<25	**<40**	44.2 – 39.2	5.0	39.2 – 36.4	2.8	-	36.4
30	**48**	19.1 – 18.0	1.1	18.0 – 17.3	0.7	-	17.3
35	**56**	24.2 – 22.5	1.7	22.5 – 21.5	1.0	-	21.5
40+	**64+**	17.8 – 17.3	0.5	17.3 – 17.0	0.3	-	17.0
Total		-	**8.4**	-	**4.8**	-	**92.2**

Note: Values may not sum due to rounding.

Table 88 and Table 89 present the calculation of MAIS injuries resulting from passenger cars striking pedestrians under regulatory alternative #1. MAIS injuries can be calculated by subtracting the number of MAIS+F one level above from the MAIS+F injuries.

Table 88: Regulatory Alternative #1: MAIS for Passenger Cars (MAIS 1 to MAIS 3)

Injury Severity		MAIS 1		MAIS 2		MAIS 3	
Speed Limit (mph/km/h)		Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total
<25	**<40**	394.3 – 217.5	176.8	217.5 – 92.3	125.2	92.3 – 37.4	54.9
30	**48**	129.4 – 73.5	55.9	73.5 – 34.0	39.5	34.0 – 16.2	17.9
35	**56**	261.0 – 143.3	117.7	143.3 – 59.2	84.1	59.2 – 20.5	38.7
40+	**64+**	239.8 – 115.1	124.7	115.1 – 47.6	67.5	47.6 – 15.0	32.6
Total		**-**	**475.2**	**-**	**316.2**	**-**	**144.1**

Note: Values may not sum due to rounding.

Table 89: Regulatory Alternative #1:MAIS for Passenger Cars (MAIS 4 to Fatalities)

Injury Severity		MAIS 4		MAIS 5		Fatality	
Speed Limit (mph/km/h)		Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total
<25	**<40**	37.4 – 32.5	4.8	32.5 – 29.4	3.1	-	29.4
30	**48**	16.2 – 14.9	1.2	14.9 – 14.0	0.9	-	14.0
35	**56**	20.5 – 18.7	1.7	18.7 – 17.4	1.3	-	17.4
40+	**64+**	15.0 – 14.3	0.7	14.3 – 13.7	0.6	-	13.7
Total		**-**	**8.5**	**-**	**5.9**	**-**	**74.6**

Note: Values may not sum due to rounding.

Table 90 and Table 91 present the total incremental benefits for LTVs for regulatory alternative #1. Incremental benefits are the difference in MAIS injuries between the baseline and the regulatory alternative. As a result of the regulatory alternative #1, a total of approximately 17.5 fatalities resulting from cases in which an LTV strikes a pedestrian would be mitigated. Note that the countermeasures to meet the requirements specified in the proposed rule mitigate fatalities which become less severe non-fatal injuries and mitigate more severe non-fatal injuries which become less severe injuries. Although the net total of non-fatal injuries from MAIS1 to MAIS 5 increase under the proposed rule due to the trickle-down of those fatalities and non-fatal injuries, overall there is a benefit at each MAIS level.

Table 90: Regulatory Alternative #1: Total Annual Incremental Benefits for LTV (MAIS 1 to MAIS 3)

Injury Severity		MAIS 1			MAIS 2			MAIS 3		
Speed Limit (mph/km/h)		Baseline	Regulatory Alternative #1	Benefits	Baseline	Regulatory Alternative #1	Benefits	Baseline	Regulatory Alternative #1	Benefits
<25	**<40**	168.4	176.8	-8.5	125.5	125.2	0.3	57.6	54.9	2.6
30	**48**	53.0	55.9	-2.9	39.3	39.5	-0.2	18.4	17.9	0.5
35	**56**	112.2	117.7	-5.6	84.4	84.1	0.4	41.1	38.7	2.3
40+	**64+**	120.3	124.7	-4.4	67.8	67.5	0.3	34.7	32.6	2.1
Total		**453.9**	**475.2**	**-21.3**	**317.0**	**316.2**	**0.8**	**151.7**	**144.1**	**7.6**

Note: Values may not sum due to rounding.

Table 91: Regulatory Alternative #1:Total Annual Incremental Benefits LTVs (MAIS 4 to Fatalities)

Injury Severity		MAIS 4			MAIS 5			Fatality		
Speed Limit (mph/km/h)		Baseline	Regulatory Alternative #1	Benefits	Baseline	Regulatory Alternative #1	Benefits	Baseline	Regulatory Alternative #1	Benefits
<25	**<40**	5.0	4.8	0.2	2.8	3.1	-0.3	36.4	29.4	6.9
30	**48**	1.1	1.2	-0.1	0.7	0.9	-0.2	17.3	14.0	3.3
35	**56**	1.7	1.7	-0.1	1.0	1.3	-0.3	21.5	17.4	4.1
40+	**64+**	0.5	0.7	-0.2	0.3	0.6	-0.3	17.0	13.7	3.2
Total		**8.4**	**8.5**	**-0.1**	**4.8**	**5.9**	**-1.1**	**92.2**	**74.6**	**17.5**

Note: Values may not sum due to rounding.

Table 92 presents the total annual incremental benefits for both vehicle types. Under regulatory alternative #1, approximately 40.1 fatalities resulting from either a passenger car or LTV striking a pedestrian would be mitigated. As those fatalities were mitigated, the number of non-fatal injuries across the MAIS 1-5 scale increases by approximately the same amount.

Table 92: Regulatory Alternative #1: Total Annual Incremental Benefits

Injury Severity	Benefits by Vehicle Type		Total Benefits
	Passenger Cars	LTVs	
MAIS 1	-17.4	-21.3	-38.7
MAIS 2	-3.8	0.8	-2.9
MAIS 3	4.7	7.6	12.3
MAIS 4	-0.8	-0.1	-0.9
MAIS 5	-2.3	-1.1	-3.4
Fatalities	22.6	17.5	40.1

Note: Values may not sum due to rounding. Negative values represent an increase in the number of injuries at that specific severity.

9.1.3. Costs

The subsection presents the costs associated with regulatory alternative #1. Given the findings of the teardown study, this analysis assumes that the costs associated with meeting the requirements under this regulatory alternative would be similar to that of the proposed rule. Therefore, this analysis uses the estimates from the main analysis to establish the cost associated with this regulatory alternative. We request comment on this assumption.

9.1.4. Cost-Effectiveness and Net Benefits

This subsection presents the cost-effectiveness and benefit cost analyses for regulatory alternative #1. Table 93 presents the conversion of injury benefits by MAIS level to equivalent fatalities for regulatory alternative #1. Based on this conversion, the proposed rule would prevent approximately 21.3 and 17.6 equivalent fatalities resulting from head injuries in cases that a passenger car or LTV strikes a pedestrian, respectively.

Table 93: Regulatory Alternative #1: Conversion of MAIS Injury to Equivalent Fatalities

Injury Severity	Passenger Cars			LTVs		
	Benefits	Fraction of VSL	Equivalent Fatalities	Benefits	Fraction of VSL	Equivalent Fatalities
MAIS 1	-17.4	0.003	-0.052	-21.3	0.003	-0.064
MAIS 2	-3.8	0.047	-0.176	0.8	0.047	0.039
MAIS 3	4.7	0.105	0.496	7.6	0.105	0.798
MAIS 4	-0.8	0.266	-0.203	-0.1	0.266	-0.028
MAIS 5	-2.3	0.593	-1.350	-1.1	0.593	-0.659
Fatal	22.6	1.000	22.580	17.5	1.000	17.547
Total			**21.295**			**17.633**

Note: Values may not sum due to rounding.

Table 94 presents the discounted equivalent fatalities for regulatory alternative #1. When discounted at three and seven percent, the present value of the equivalent fatalities ranges are approximately 32.3 and 26.2, respectively.

Table 94 : Regulatory Alternative #1: Discounted Equivalent Fatalities

Category	Discounted at 3%			Discounted at 7%		
	Equivalent Fatalities	**Adjustment Factor**	**Discounted Equivalent Fatalities**	**Equivalent Fatalities**	**Adjustment Factor**	**Discounted Equivalent Fatalities**
Passenger Cars	21.29	0.8354	17.79	21.29	0.6816	14.51
LTVs	17.63	0.8216	14.49	17.63	0.6626	11.68
Total			**32.28**			**26.20**

Note: Values may not sum due to rounding.

Table 95 presents the cost per equivalent life saved for regulatory alternative #3. When discounted at three and seven percent, the cost per equivalent life saved for regulatory alternative #3 is approximately $1.87 million. As the cost per equivalent life saved is less than the VSL, this regulatory alternative is considered to be cost-effective.

Table 95: Regulatory Alternative #1: Cost per Equivalent Life Saved

Discount Rate	Equivalent Lives Saved	Total Cost (Millions)	Cost per Equivalent Life Saved (Millions)
3%	32.28	$60.43	$1.87
7%	26.20	$48.94	$1.87

Table 96 presents the calculation of monetized benefits for regulatory alternative #1. Monetized benefits are calculated by multiplying the number of non-fatal injuries and fatalities prevented by their corresponding comprehensive costs. Monetized benefits for passenger cars and LTVs are estimated at approximately $253.6 million and $210.2 million, respectively.

Table 96: Regulatory Alternative #1: Calculation of Monetized Benefits

Injury Severity	Passenger Cars			LTVs		
	Benefits	**Comprehensive Cost**	**Monetized Benefits**	**Benefits**	**Comprehensive Cost**	**Monetized Benefits**
MAIS 1	-17.4	$44,752	-$777,582	-21.3	$44,752	-$953,025
MAIS 2	-3.8	$541,175	-$2,031,986	0.8	$541,175	$444,049
MAIS 3	4.7	$1,286,349	$6,071,253	7.6	$1,286,349	$9,782,263
MAIS 4	-0.8	$3,194,328	-$2,431,913	-0.1	$3,194,328	-$338,052
MAIS 5	-2.3	$7,307,122	-$16,635,602	-1.1	$7,307,122	-$8,114,720
Fatal	22.6	$11,930,276	$269,386,579	17.5	$11,930,276	$209,339,104
Total			**$253,580,748**			**$210,159,618**

Note: Values may not sum due to rounding.

Table 97 presents the discounted monetized benefits associated with the regulatory alternative #1. When discounted at three and seven percent, monetized benefits are approximately $384.5 million and $312.1 million, respectively.

Table 97: Regulatory Alternative #1: Discounted Monetized Benefits (Millions)

Category	Discounted at 3%			Discounted at 7%		
	Monetized Benefits	Adjustment Factor	Discounted Monetized Benefits	Monetized Benefits	Adjustment Factor	Discounted Monetized Benefits
Passenger Cars	$253.58	0.8354	$211.84	$253.58	0.6816	$172.84
LTVs	$210.16	0.8216	$172.67	$210.16	0.6626	$139.25
Total			**$384.51**			**$312.09**

Note: Values may not sum due to rounding.

Table 98 displays the net benefits associated with the regulatory alternative #1. When discounted at three and seven percent, net benefits are approximately $324.1 million and $263.2 million, respectively. Net benefits greater than zero for discount rates indicate that the proposed rule is net beneficial.

Table 98: Regulatory Alternative #1: Summary of Net Benefits (Millions)

Discount Rate	Monetized Benefits	Total Cost	Net Benefits
3%	$384.51	$60.43	$324.08
7%	$312.09	$48.94	$263.15

Note: Values may not sum due to rounding.

9.2. Regulatory Alternative #3

This regulatory alternative considers a more stringent condition in which the requirements specified in the proposed rule would be applicable to the entire Hood Top, i.e., the Test Area would encompass the entire Hood Top. Under this regulatory alternative, the HIC Unlimited Area would no longer exist. Any point within the boundary of the Hood Top would be a valid impact point. In this case, the HIC1000 Area would be required to cover at least two-thirds of the

Hood Top and HIC1700 Area would cover one-third of the Hood Top. The following subsections presents the target population, benefits, costs, and cost-effectiveness and benefit cost analyses for this regulatory alternative.

9.2.1. Target Population

This subsection presents the target population for regulatory alternative #3. For regulatory alternative #3, the initial target population is the same as the target population for the proposed rule. Furthermore, the adjustments for PAEB and head injuries as MAIS are the same as those for the target population for the proposed rule. However, for this regulatory alternative there is no adjustment for the Test Area as this regulatory alternative covers the entire Hood Top.

Table 99 and Table 100 present the head injury as MAIS adjusted target population for passenger cars and LTVs, respectively. Note that the head injury as MAIS adjusted target population for this regulatory alternative is the same as the main analysis.

Table 99: Regulatory Alternative #3: Head Injury as MAIS Adjusted Target Population for Passenger Cars

Injury Severity	**Speed Limit (mph/km/h)**				**TOTAL**
	<25	**30**	**35**	**40+**	
	<40	**48**	**56**	**64+**	
MAIS 1	396	146	283	312	1,138
MAIS 2	149	55	119	140	464
MAIS 3	72	27	65	80	244
MAIS 4	7	2	6	8	24
MAIS 5	4	1	4	5	15
Fatalities	41	39	87	304	471

Note: Fatalities and non-fatal injuries are rounded to the nearest whole number for presentation purposes.

Table 100: Regulatory Alternative #3: Head Injury as MAIS Adjusted Target Population for LTVs

Injury Severity	Speed Limit (mph/km/h)				
	<25	30	35	40+	TOTAL
	<40	48	56	64+	
MAIS 1	225	72	156	161	614
MAIS 2	168	57	129	145	499
MAIS 3	77	28	67	81	253
MAIS 4	7	3	6	8	24
MAIS 5	4	2	4	5	14
Fatalities	49	39	82	280	449

Note: Fatalities and non-fatal injuries are rounded to the nearest whole number for presentation purposes.

Table 101 and Table 102 present the impact speed adjusted target population for regulatory alternative #3 for passenger cars and LTVs, respectively. The impact speed adjusted target population for this regulatory alternative reflects the impact speed adjustment factors presented in Table 20 on the passenger car and LTV target population presented in Table 99 and Table 100.

Table 101: Regulatory Alternative #3: Impact Speed Adjusted Target Population for Passenger Cars

Injury Severity	Speed Limit (mph/km/h)				
	<25	30	35	40+	TOTAL
	<40	48	56	64+	
MAIS 1	396	145	271	312	1,125
MAIS 2	149	51	104	88	392
MAIS 3	72	23	53	46	195
MAIS 4	7	1	2	1	11
MAIS 5	4	1	1	0	6
Fatalities	41	23	31	25	119

Note: Fatalities and non-fatal injuries are rounded to the nearest whole number for presentation purposes.

Table 102: Regulatory Alternative #3: Impact Speed Adjusted Target Population for LTVs

Injury Severity	Speed Limit (mph/km/h)				
	<25	30	35	40+	TOTAL
	<40	48	56	64+	
MAIS 1	225	71	150	161	607
MAIS 2	168	53	113	91	424
MAIS 3	77	25	55	46	203
MAIS 4	7	2	2	1	11
MAIS 5	4	1	1	0	6
Fatalities	49	23	29	23	123

Note: Fatalities and non-fatal injuries are rounded to the nearest whole number for presentation purposes.

9.2.2. Benefits

This subsection presents the calculation of benefits for regulatory alternative #3, based on the test results in Appendix G. The probability of injury in the tests was estimated for passenger cars under the condition that the vehicles would be compliant with regulatory alternative #3 (Table 156). The calculation of incremental benefits for this regulatory alternative follow the same methods as those in the main analysis. However, we must note the two differences from the methods in the main analysis when estimating benefits for this regulatory alternative. When calculating benefits for this regulatory alternative, the first difference from the methods employed in the main analysis is not adjusting the target population to account for the Test Area because this regulatory alternative covers the entire Hood Top Similarly, the second difference in the methods is that we treat all noncompliant points on the entire Hood Top in the test results in Appendix G rather than only treating those in the Test Area.

Table 103 presents the decrease in probability of fatality and injuries for passenger cars under regulatory alternative #3. Overall, we find that the regulatory alternative #3 is approximately 38.3 percent effective in mitigating fatalities for passenger cars.[34]

Table 103: Regulatory Alternative #3: Percentage Change in the Probability of Fatal and Non-Fatal Injuries for Passenger Cars

Injury Severity	Percentage Change in Probability
MAIS 1+F	0.4%
MAIS 2+F	6.6%
MAIS 3+F	16.1%
MAIS 4+F	29.8%
MAIS 5+F	33.2%
Fatalities	38.3%

Table 104 and Table 105 present the change in MAIS+F injuries for passenger cars under

[34] Calculations in Appendix G: Calculations for Regulatory Alternatives.

regulatory alternative #3. It is important to note that the table presents the number of non-fatal injuries by MAIS+F rather than MAIS. For presentation purposes, these two tables are split. Table 104 presents the portion of the change in MAIS+F injuries represented by MAIS 1+F to MAIS 3+F and Table 105 presents the portion of the change in MAIS+F injuries represented by MAIS 4+F to fatalities. The change in MAIS+F injuries is calculated by reflecting the percentage change in the probability of fatal and non-fatal injuries associated with this regulatory alternative (Table 103) on the MAIS+F injuries in the target population.

Table 104: Regulatory Alternative #3: Change in MAIS+F Injuries for Passenger Cars (MAIS 1+F to MAIS 3+F)

Injury Severity		**MAIS 1+F**			**MAIS 2+F**			**MAIS 3+F**		
Speed Limit (mph/km/h)		**TP (Baseline)**	**% Reduction**	**Regulatory Alternative #3**	**TP (Baseline)**	**% Reduction**	**Regulatory Alternative #3**	**TP (Baseline)**	**% Reduction**	**Regulatory Alternative #3**
<25	**<40**	668.3	0.4%	665.4	272.3	6.6%	254.3	122.9	16.1%	103.2
30	**48**	244.7	0.4%	243.6	99.4	6.6%	92.9	48.6	16.1%	40.8
35	**56**	463.7	0.4%	461.6	192.3	6.6%	179.6	88.0	16.1%	73.9
40+	**64+**	471.6	0.4%	469.5	159.3	6.6%	148.8	71.7	16.1%	60.1
Total		**1,848.3**	-	**1,840.1**	**723.4**	-	**675.5**	**331.1**	-	**277.9**

Note: Values may not sum due to rounding.

Table 105: Regulatory Alternative #3: Change in MAIS+F Injuries for Passenger Cars (MAIS 4+F to Fatality)

Injury Severity		**MAIS 4+F**			**MAIS 5+F**			**Fatalities**		
Speed Limit (mph/km/h)		**TP (Baseline)**	**% Reduction**	**Regulatory Alternative #3**	**TP (Baseline)**	**% Reduction**	**Regulatory Alternative #3**	**TP (Baseline)**	**% Reduction**	**Regulatory Alternative #3**
<25	**<40**	51.0	29.8%	35.8	44.4	33.2%	29.6	40.6	38.3%	25.0
30	**48**	25.3	29.8%	17.7	23.8	33.2%	15.9	23.0	38.3%	14.2
35	**56**	34.5	29.8%	24.2	32.3	33.2%	21.5	30.8	38.3%	19.0
40+	**64+**	25.8	29.8%	18.1	25.1	33.2%	16.8	24.7	38.3%	15.2
Total		**136.5**	-	**95.8**	**125.6**	-	**83.8**	**119.1**	-	**73.5**

Note: Values may not sum due to rounding.

Table 106 and Table 107 present the calculation of MAIS injuries resulting from passenger cars striking pedestrians under the baseline for regulatory alternative #3. MAIS injuries can be calculated by subtracting the number of MAIS+F one level above from the MAIS+F injuries. For example, to calculate MAIS 1 injuries, we would subtract MAIS 2+F from the MAIS 1+F total.

Table 106: Regulatory Alternative #3: Baseline MAIS for Passenger Cars (MAIS 1 to MAIS 3)

Injury Severity		**MAIS 1**		**MAIS 2**		**MAIS 3**	
Speed Limit (mph/km/h)		**Calculation Based on MAIS+F**	**MAIS Total**	**Calculation Based on MAIS+F**	**MAIS Total**	**Calculation Based on MAIS+F**	**MAIS Total**
<25	**<40**	668.3 – 272.3	396.0	272.3 – 122.9	149.4	122.9 – 51.0	71.9
30	**48**	244.7 – 99.4	145.2	99.4 – 48.6	50.9	48.6 – 25.3	23.3
35	**56**	463.7 – 192.3	271.4	192.3 – 88.0	104.3	88.0 – 34.5	53.4
40+	**64+**	471.6 – 159.3	312.2	159.3 – 71.7	87.7	71.7 – 25.8	45.9
Total		**-**	**1,124.9**	-	**392.3**	-	**194.6**

Note: Values may not sum due to rounding.

Table 107: Regulatory Alternative #3: Baseline MAIS for Passenger Cars (MAIS 4 to Fatalities)

Injury Severity		**MAIS 4**		**MAIS 5**		**Fatality**	
Speed Limit (mph/km/h)		**Calculation Based on MAIS+F**	**MAIS Total**	**Calculation Based on MAIS+F**	**MAIS Total**	**Calculation Based on MAIS+F**	**MAIS Total**
<25	**<40**	51.0 – 44.4	6.6	44.4 – 40.6	3.8	-	40.6
30	**48**	25.3 – 23.8	1.4	23.8 – 23.0	0.8	-	23.0
35	**56**	34.5 – 32.3	2.3	32.3 – 30.8	1.4	-	30.8
40+	**64+**	25.8 – 25.1	0.7	25.1 – 24.7	0.4	-	24.7
Total		-	**10.9**	-	**6.5**	**-**	**119.1**

Note: Values may not sum due to rounding.

Table 108 and Table 109 present the calculation of MAIS injuries resulting from passenger cars striking pedestrians under regulatory alternative #3. MAIS injuries can be calculated by subtracting the number of MAIS+F one level above from the MAIS+F injuries.

Table 108: Regulatory Alternative #3: MAIS for Passenger Cars (MAIS 1 to MAIS 3)

Injury Severity		MAIS 1		MAIS 2		MAIS 3	
Speed Limit (mph/km/h)		Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total
<25	**<40**	665.4 – 254.3	411.1	254.3 – 103.2	151.2	103.2 – 35.8	67.4
30	**48**	243.6 – 92.9	150.7	92.9 – 40.8	52.1	40.8 – 17.7	23.0
35	**56**	461.6 – 179.6	282.1	179.6 – 73.9	105.7	73.9 – 24.2	49.6
40+	**64+**	469.5 – 148.8	320.7	148.8 – 60.1	88.6	60.1 – 18.1	42.1
Total		-	**1,164.5**	-	**397.6**	-	**182.1**

Note: Values may not sum due to rounding.

Table 109: Regulatory Alternative #3: MAIS for Passenger Cars for (MAIS 4 to Fatalities)

Injury Severity		MAIS 4		MAIS 5		Fatality	
Speed Limit (mph/km/h)		Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total
<25	**<40**	35.8 – 29.6	6.1	29.6 – 25.0	4.6	-	25.0
30	**48**	17.7 – 15.9	1.8	15.9 – 14.2	1.7	-	14.2
35	**56**	24.2 – 21.5	2.7	21.5 – 19.0	2.5	-	19.0
40+	**64+**	18.1 – 16.8	1.3	16.8 – 15.2	1.5	-	15.2
Total		-	**12.0**	-	**10.4**	-	**73.5**

Note: Values may not sum due to rounding.

Table 110 and Table 111 present the total incremental benefits for passenger cars for regulatory alternative #3. Incremental benefits are the difference in MAIS injuries under the baseline and the regulatory alternative. Under this regulatory alternative, a total of 45.6 fatalities resulting from cases in which a passenger car strikes a pedestrian would be mitigated. Note that the countermeasures to meet the requirements specified in the proposed rule mitigate fatalities which become less severe non-fatal injuries and mitigate more severe non-fatal injuries which become less severe injuries. Although the net total of non-fatal injuries from MAIS1 to MAIS 5 increase under the proposed rule due to the trickle-down of those fatalities and non-fatal injuries, overall there is a benefit at each MAIS level.

Table 110: Regulatory Alternative #3: Total Annual Incremental Benefits for Passenger Cars (MAIS 1 to MAIS 3)

Injury Severity		MAIS 1			MAIS 2			MAIS 3		
Speed Limit (mph/km/h)		Baseline	Regulatory Alt #3	Benefits	Baseline	Regulatory Alt #3	Benefits	Baseline	Regulatory Alt #3	Benefits
<25	**<40**	396.0	411.1	-15.1	149.4	151.2	-1.7	71.9	67.4	4.5
30	**48**	145.2	150.7	-5.5	50.9	52.1	-1.2	23.3	23.0	0.3
35	**56**	271.4	282.1	-10.7	104.3	105.7	-1.4	53.4	49.6	3.8
40+	**64+**	312.2	320.7	-8.5	87.7	88.6	-1.0	45.9	42.1	3.8
Total		**1,124.9**	**1,164.5**	**-39.7**	**392.3**	**397.6**	**-5.3**	**194.6**	**182.1**	**12.5**

Note: Values may not sum due to rounding.

Table 111: Regulatory Alternative #3: Total Annual Incremental Benefits for Passenger Cars (MAIS 4 to Fatalities)

Injury Severity		MAIS 4			MAIS 5			Fatality		
Speed Limit (mph/km/h)		Baseline	Regulatory Alt #3	Benefits	Baseline	Regulatory Alt #3	Benefits	Baseline	Regulatory Alt #3	Benefits
<25	**<40**	6.6	6.1	0.4	3.8	4.6	-0.8	40.6	25.0	-0.8
30	**48**	1.4	1.8	-0.4	0.8	1.7	-0.9	23.0	14.2	-0.9
35	**56**	2.3	2.7	-0.4	1.4	2.5	-1.1	30.8	19.0	-1.1
40+	**64+**	0.7	1.3	-0.7	0.4	1.5	-1.1	24.7	15.2	-1.1
Total		**10.9**	**12.0**	**-1.0**	**6.5**	**10.4**	**-3.9**	**119.1**	**73.5**	**45.6**

Note: Values may not sum due to rounding.

Table 112 presents the decrease in probability of fatality and injuries for passenger cars under regulatory alternative #3. Overall, we find that regulatory alternative #3 is approximately 49.1 percent effective in mitigating fatalities for LTVs.[35]

Table 112: Regulatory Alternative #3: Percentage Change in the Probability of Fatal and Non-Fatal Injuries for LTVs

Injury Severity	**Percentage Change in Probability**
MAIS 1+F	0.9%
MAIS 2+F	11.6%
MAIS 3+F	24.6%
MAIS 4+F	40.4%
MAIS 5+F	44.0%
Fatalities	49.1%

Table 113 and Table 114 present the change in MAIS+F injuries for LTVs for this regulatory alternative. It is important to note that the table presents the number of non-fatal injuries by MAIS+F rather than MAIS. For presentation purposes, these two tables are split. Table 113 presents the portion of the change in MAIS+F injuries represented by MAIS 1+F to MAIS 3+F and Table 114 presents the portion of the change in MAIS+F injuries represented by MAIS 4+F to fatalities. The change in MAIS+F injuries is calculated by reflecting the percentage change in the probability of fatal and non-fatal injuries associated with this regulatory alternative (Table 112) on the MAIS+F injuries in the target population.

[35] Calculations in Appendix G: Calculations for Regulatory Alternatives.

Table 113: Regulatory Alternative #3: Change in MAIS+F Injuries for LTVs (MAIS 1+F to MAIS 3+F)

Injury Severity		MAIS 1			MAIS 2			MAIS 3		
Speed Limit (mph/km/h)		TP (Baseline)	% Reduction	Regulatory Alternative #3	TP (Baseline)	% Reduction	Regulatory Alternative #3	TP (Baseline)	% Reduction	Regulatory Alternative #3
<25	**<40**	528.9	0.9%	524.0	303.8	11.6%	268.7	136.1	24.6%	102.5
30	**48**	173.6	0.9%	172.0	102.7	11.6%	90.8	50.2	24.6%	37.8
35	**56**	350.1	0.9%	346.9	200.2	11.6%	177.0	87.3	24.6%	65.8
40+	**64+**	321.7	0.9%	318.7	160.8	11.6%	142.2	70.2	24.6%	52.9
Total		**1,374.3**	**-**	**1,361.5**	**767.5**	**-**	**678.7**	**343.7**	**-**	**259.0**

Note: Values may not sum due to rounding.

Table 114: Regulatory Alternative #3: Change in MAIS+F Injuries for LTVs (MAIS 4+F to Fatality)

Injury Severity		MAIS 4			MAIS 5			Fatalities		
Speed Limit (mph/km/h)		TP (Baseline)	% Reduction	Regulatory Alternative #3	TP (Baseline)	% Reduction	Regulatory Alternative #3	TP (Baseline)	% Reduction	Regulatory Alternative #3
<25	**<40**	59.1	40.4%	35.2	52.4	44.0%	29.3	48.6	49.1%	24.7
30	**48**	25.6	40.4%	15.3	24.1	44.0%	13.5	23.2	49.1%	11.8
35	**56**	32.4	40.4%	19.3	30.1	44.0%	16.9	28.8	49.1%	14.6
40+	**64+**	23.8	40.4%	14.2	23.1	44.0%	12.9	22.7	49.1%	11.5
Total		**140.8**	**-**	**84.0**	**129.7**	**-**	**72.6**	**123.2**	**-**	**62.7**

Note: Values may not sum due to rounding.

Table 115 and Table 116 present the calculation of MAIS injuries resulting from LTVs striking pedestrians under the baseline for regulatory alternative #3. MAIS injuries can be calculated by subtracting the number of MAIS+F one level above from the MAIS+F injuries. For example, to calculate MAIS 1 injuries, we would subtract MAIS 2+F from the MAIS 1+F total.

Table 115: Regulatory Alternative #3: Baseline MAIS for LTVs (MAIS 1 to MAIS 3)

Injury Severity		MAIS 1		MAIS 2		MAIS 3	
Speed Limit (mph/km/h)		Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total
<25	<40	528.9 – 303.8	225.1	303.8 – 136.1	167.8	136.1 – 59.1	77.0
30	48	173.6 – 102.7	70.9	102.7 – 50.2	52.5	50.2 – 25.6	24.6
35	56	350.1 – 200.2	149.9	200.2 – 87.3	112.9	87.3 – 32.4	54.9
40+	64+	321.7 – 160.8	160.9	160.8 – 70.2	90.6	70.2 – 23.8	46.4
Total		-	**606.8**	-	**423.8**	-	**202.9**

Note: Values may not sum due to rounding.

Table 116: Regulatory Alternative #3: Baseline MAIS for LTVs (MAIS 4 to Fatalities)

Injury Severity		MAIS 4		MAIS 5		Fatality	
Speed Limit (mph/km/h)		Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total
<25	<40	59.1 – 52.4	6.7	52.4 – 48.6	3.7	-	48.6
30	48	25.6 – 24.1	1.5	24.1 – 23.2	0.9	-	23.2
35	56	32.4 – 30.1	2.2	30.1 – 28.8	1.4	-	28.8
40+	64+	23.8 – 23.1	0.7	23.1 – 22.7	0.4	-	22.7
Total		-	**11.2**	-	**6.4**	-	**123.2**

Note: Values may not sum due to rounding.

Table 117 and Table 118 present the calculation of MAIS injuries resulting from LTVs striking pedestrians under regulatory alternative #3. MAIS injuries can be calculated by subtracting the number of MAIS+F one level above from the MAIS+F injuries.

Table 117: Regulatory Alternative #3: MAIS for LTVs (MAIS 1 to MAIS 3)

Injury Severity		MAIS 1		MAIS 2		MAIS 3	
Speed Limit (mph/km/h)		Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total
<25	**<40**	524.0 – 268.7	255.3	268.7 – 102.5	166.1	102.5 – 35.2	67.3
30	**48**	172.0 – 90.8	81.2	90.8 – 37.8	53.0	37.8 – 15.3	22.6
35	**56**	346.9 – 177.0	169.8	177.0 – 65.8	111.2	65.8 – 19.3	46.5
40+	**64+**	318.7 – 142.2	176.5	142.2 – 52.9	89.3	52.9 – 14.2	38.7
Total		**-**	**682.8**	**-**	**419.6**	**-**	**175.1**

Note: Values may not sum due to rounding.

Table 118: Regulatory Alternative #3: MAIS for LTVs (MAIS 4 to Fatalities)

Injury Severity		MAIS 4		MAIS 5		Fatality	
Speed Limit (mph/km/h)		Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total	Calculation Based on MAIS+F	MAIS Total
<25	**<40**	35.2 – 29.3	5.9	29.3 – 24.7	4.6	-	24.7
30	**48**	15.3 – 13.5	1.8	13.5 – 11.8	1.7	-	11.8
35	**56**	19.3 – 16.9	2.4	16.9 – 14.6	2.2	-	14.6
40+	**64+**	14.2 – 12.9	1.2	12.9 – 11.5	1.4	-	11.5
Total		-	**11.4**	-	**9.9**	-	**62.7**

Note: Values may not sum due to rounding.

Table 119 and Table 120 present the total incremental benefits for LTVs for regulatory alternative #3. Incremental benefits are the difference in MAIS injuries under the baseline and the regulatory alternative. Under this regulatory alternative, a total of 60.6 fatalities resulting from cases in which an LTV strikes a pedestrian would be mitigated. Note that the countermeasures to meet the requirements specified in the proposed rule mitigate fatalities which become less severe non-fatal injuries and mitigate more severe non-fatal injuries which become less severe injuries. Although the net total of non-fatal injuries from MAIS1 to MAIS 5 increase under the proposed rule due to the trickle-down of those fatalities and non-fatal injuries, overall there is a benefit at each MAIS level.

Table 119: Regulatory Alternative #3: Total Annual Incremental Benefits for LTVs (MAIS 1 to MAIS 3)

Injury Severity		MAIS 1			MAIS 2			MAIS 3		
Speed Limit (mph/km/h)		**Baseline**	**Regulatory Alt #3**	**Benefits**	**Baseline**	**Regulatory Alt #3**	**Benefits**	**Baseline**	**Regulatory Alt #3**	**Benefits**
<25	**<40**	225.1	255.3	-30.2	167.8	166.1	1.6	77.0	67.3	9.7
30	**48**	70.9	81.2	-10.3	52.5	53.0	-0.5	24.6	22.6	2.0
35	**56**	149.9	169.8	-19.9	112.9	111.2	1.7	54.9	46.5	8.4
40+	**64+**	160.9	176.5	-15.6	90.6	89.3	1.3	46.4	38.7	7.7
Total		**606.8**	**682.8**	**-76.0**	**423.8**	**419.6**	**4.1**	**202.9**	**175.1**	**27.8**

Note: Values may not sum due to rounding.

Table 120: Regulatory Alternative #3: Total Annual Incremental Benefits for LTVs (MAIS 4 to Fatalities)

Injury Severity		MAIS 4			MAIS 5			Fatality		
Speed Limit (mph/km/h)		**Baseline**	**Regulatory Alt #3**	**Benefits**	**Baseline**	**Regulatory Alt #3**	**Benefits**	**Baseline**	**Regulatory Alt #3**	**Benefits**
<25	**<40**	6.7	5.9	0.8	3.7	4.6	-0.9	48.6	24.7	23.9
30	**48**	1.5	1.8	-0.3	0.9	1.7	-0.8	23.2	11.8	11.4
35	**56**	2.2	2.4	-0.2	1.4	2.2	-0.9	28.8	14.6	14.1
40+	**64+**	0.7	1.2	-0.6	0.4	1.4	-1.0	22.7	11.5	11.1
Total		**11.2**	**11.4**	**-0.2**	**6.4**	**9.9**	**-3.5**	**123.2**	**62.7**	**60.6**

Note: Values may not sum due to rounding.

Table 121 presents a summary of the annual benefits for regulatory alternative #3. Under regulatory alternative #3, a total of approximately 106.2 fatalities would be mitigated annually. As those fatalities were mitigated, the number of non-fatal injuries across the MAIS 1-5 scale increases as those fatalities trickle-down into less severe injuries.

Table 121: Regulatory Alternative #3: Summary of Annual Benefits

Injury Severity	Benefits by Vehicle Type		Total
	Passenger Cars	LTVs	
MAIS 1	-39.7	-76.0	-115.7
MAIS 2	-5.3	4.1	-1.2
MAIS 3	12.5	27.8	40.3
MAIS 4	-1.0	-0.2	-1.2
MAIS 5	-3.9	-3.5	-7.4
Fatalities	45.6	60.6	106.2

Note: Values may not sum due to rounding.

9.2.3. Costs

Although this analysis was able to quantify the benefits associated with this regulatory alternative, this analysis is unable to quantify the potential costs associated with this regulatory alternative. Instead, we provide a qualitative discussion of the potential costs associated with this more stringent requirement. However, as a result of this limitation, this analysis is unable to calculate the cost-effectiveness and benefit-cost measures for this regulatory alternative. Potential costs associated with this regulatory alternative include hardware costs, fuel economy costs, and one-time redesign costs. In the main analysis, we noted that vehicle manufacturers of vehicles already meet similar pedestrian protection requirements in other markets (e.g., EU market) and, as a result, would not incur any one-time costs associated with redesigning vehicle hoods to be in compliance with the requirements. However, as vehicle manufacturers are not subject to the requirements specified in this regulatory alternative in other markets, we assume that they would incur a one-time cost to redesign their hoods to meet this more stringent requirement. Additionally, the more stringent requirements may also potentially restrict vehicle design. These potential restrictions would be specific to the front end or profile of applicable vehicles when vehicles must have an adequate protective gap between the hood and hinges as well as other components to meet the HIC requirement. As a result, these restrictions may potentially impact the sales of such vehicles. However, we note that all vehicles would be similarly affected, so a particular vehicle model would not be disadvantaged compared to another. Furthermore, we request comment on the feasibility of this more stringent requirement. We also consider the potential incremental costs associated with hardware. However, this analysis is unable to quantify any incremental costs associated with the hardware necessary to meet the requirements specified in this regulatory alternative. Lastly, given the changes to the hardware or additional hardware used to meet this more stringent requirement, it is expected that this regulatory alternative would have an impact on fuel economy. As a result, the additional weight of hoods would increase fuel costs over the course of a vehicle's lifetime.

9.2.4. Break-Even Analysis

As there are limitation regarding the feasibility and costs associated with regulatory alternative #3, we include a break-even analysis rather than cost-effectiveness and benefit cost analyses. This break-even analysis considers the cost at which this regulatory alternative would be net cost-effective and net beneficial.

Table 122 presents the conversion of injury benefits by MAIS level to equivalent fatalities for the benefits estimates under regulatory alternative #3. Under the regulatory alternative #3, a total of approximately 44.0 equivalent fatalities would be prevented in cases that a passenger car strikes a pedestrian and approximately 61.3 equivalent fatalities would be prevented in cases that an LTV strikes a pedestrian.

Table 122: Regulatory Alternative #3: Conversion of MAIS Injury to Equivalent Fatalities

Injury Severity	**Passenger Cars**			**LTVs**		
	Benefits	**Fraction of VSL**	**Total Equivalent Fatalities**	**Benefits**	**Fraction of VSL**	**Total Equivalent Fatalities**
MAIS 1	-39.7	0.003	-0.119	-76.0	0.003	-0.228
MAIS 2	-5.3	0.047	-0.249	4.1	0.047	0.194
MAIS 3	12.5	0.105	1.310	27.8	0.105	2.920
MAIS 4	-1.0	0.266	-0.275	-0.2	0.266	-0.051
MAIS 5	-3.9	0.593	-2.311	-3.5	0.593	-2.080
Fatal	45.6	1.000	45.634	60.6	1.000	60.566
Total			**43.990**			**61.320**

Note: Values may not sum due to rounding.

Table 123 presents the calculation of monetized benefits for regulatory alternative #3. Monetized benefits are calculated by multiplying the number of non-fatal injuries and fatalities prevented by their corresponding comprehensive costs. Monetized benefits under this regulatory alternative for passenger cars and LTVs are approximately $524.1 million and $730.9, respectively.

Table 123: Regulatory Alternative #3: Calculation of Monetized Benefits

MAIS Level	**Passenger Cars**			**LTVs**		
	Benefits	**Comprehensive Cost**	**Monetized Benefits**	**Benefits**	**Comprehensive Cost**	**Monetized Benefits**
MAIS 1	-39.7	$44,752	-$1,775,997	-76.0	$44,752	-$3,402,493
MAIS 2	-5.3	$541,175	-$2,866,882	4.1	$541,175	$2,231,958
MAIS 3	12.5	$1,286,349	$16,050,659	27.8	$1,286,349	$35,775,913
MAIS 4	-1.0	$3,194,328	-$3,303,358	-0.2	$3,194,328	-$611,910
MAIS 5	-3.9	$7,307,122	-$28,476,543	-3.5	$7,307,122	-$25,633,546
Fatal	45.6	$11,930,276	$544,426,171	60.6	$11,930,276	$722,563,354
Total			**$524,054,050**			**$730,923,275**

Note: Values may not sum due to rounding.

Table 124 presents the discounted equivalent lives saved for regulatory alternative #3. When discounted at three and seven percent, the annual equivalent lives saved under this regulatory alternative are approximately 87.1 and 70.6 respectively.

Table 124: Regulatory Alternative #3: Discounted Equivalent Lives Saved and Monetized Benefits

Category	Discounted at 3%			Discounted at 7%		
	Undiscounted	Adjustment Factor	Discounted	Undiscounted	Adjustment Factor	Discounted
Passenger Cars	43.99	0.8354	36.75	43.99	0.6816	29.98
LTVs	61.32	0.8216	50.38	61.32	0.6626	40.63
Total			**87.13**			**70.61**

Note: Values may not sum due to rounding.

Table 125 presents the discounted equivalent lives saved for regulatory alternative #3. When discounted at three and seven percent, annual monetized benefits under this regulatory alternative are approximately $1,038.3 million and $841.5 million, respectively.

Table 125: Regulatory Alternative #3: Discounted Monetized Benefits (Millions)

Category	Discounted at 3%			Discounted at 7%		
	Undiscounted	Adjustment Factor	Discounted	Undiscounted	Adjustment Factor	Discounted
Passenger Cars	$524.05	0.8354	$437.79	$524.05	0.6816	$357.20
LTVs	$730.92	0.8216	$600.53	$730.92	0.6626	$484.31
Total			**$1,038.32**			**$841.51**

Note: Values may not sum due to rounding.

In the main analysis, the annual cost was comprised of fuel economy costs that are incurred over the lifespan of the vehicle and, therefore, require discounting. We note that hardware costs are incurred in the year the vehicle is manufactured and, therefore, do not require discounting. Given the limitations in estimating the costs associated with regulatory alternative #3, this analysis makes the assumption the additional costs associated with this regulatory alternative will be hardware costs and, therefore not discounted.

Table 126 presents the break-even analysis for regulatory alternative #3. More specially, this analysis estimates the cost at which net benefits under this regulatory alternative would be zero. This analysis takes into account the fuel economy costs estimated in the main analysis and then estimates the additional cost (undiscounted) at which net benefits under this regulatory alternative would be zero. The additional costs associated with this regulatory alternative would be approximately $977.9 million and $792.6 million.

Table 126: Regulatory Alternative #3: Net Benefits Break-Even Analysis (Millions)

Discount Rate	**Regulatory Alternative #3: Monetized Benefits**	**Fuel Economy Cost (Main Analysis)**	**Additional Cost to Break-Even**
3%	$1,038.32	$60.43	$977.89
7%	$841.51	$48.94	$792.56

Note: Values may not sum due to rounding.

Table 127 presents the average additional cost per vehicle for the break-even analysis. This table presents the additional average cost per light vehicle across approximately 15.7 million new vehicles sold annually. More specifically, this calculation assumes the additional cost would be the same for passenger cars and LTVs. Under this assumption, this break-even analysis finds that the additional cost under this regulatory alternative is $62.28 and $50.48 when discounted at three and seven percent, respectively.

Table 127: Regulatory Alternative #3: Average Additional Cost per Vehicle for Break-Even Analysis

Discount Rate	**Additional Cost to Break-Even (Millions)**	**Average Additional Cost per Vehicle**
3%	$977.89	$62.28
7%	$792.56	$50.48

9.3. Comparison of Regulatory Alternatives

This section provides a comparison of the regulatory alternatives considered for this rulemaking.

Table 128 presents a comparison of the three regulatory alternatives. As this analysis was unable to estimate the cost for regulatory alternative #3, we are unable to estimate cost-effectiveness and net benefits measures for that regulatory alternative.

Taking into account benefits, regulatory alternative #3 is associated with the highest benefits estimates. This is not surprising considering that this alternative includes areas of the hood that are excluded under the other alternatives. Inclusion of this additional area has a two-fold effect on benefits. First, agency testing in these areas with HIC values above the proposed HIC limits add to the estimated benefits. Second, the additional included hood area adds to the target population. However, although this regulatory alternative is estimated to offer more benefits relative to the proposed rule, this regulatory alternative was not selected as the preferred alternative for the Standard No. 228 NPRM because of unknowns about the practicability and costs of having no areas excluded from the HIC requirement. However, NHTSA seeks to minimize the area excluded from HIC requirements in the final rule, and the NPRM requests comment on expanding the Test Area to include the entire Hood Top in the final rule.

When comparing regulatory alternative #1 and #2, we note that the costs would be very similar and due to data limitations are assumed to be the same. However, regulatory alternative #2 provides more benefits and is, therefore, more cost-effective and net beneficial.

Table 128: Comparison of Regulatory Alternatives (Millions)

Regulatory Option	Cost		Equivalent Lives Saved		Cost per Equivalent Life Saved		Monetized Benefits		Net Benefits	
	3%	7%	3%	7%	3%	7%	3%	7%	3%	7%
#1: Requirements are the same as the EU interpretation of GTR 9 regarding test area (GTR 9 Amendment 3)	$60.43	$48.94	32.28	26.20	$1.87	$1.87	$384.51	$312.09	$324.08	$263.15
#2: Proposed Rule	$60.43	$48.94	54.87	44.46	$1.10	$1.10	$653.76	$529.74	$593.33	$480.79
#3: Requirements apply to the entire Hood Top (No HIC Unlimited Area)	-	-	87.13	70.61	-	-	$1,038.3	$841.51	-	-

Note: Values may not sum due to rounding.

10. Regulatory Flexibility Act and Unfunded Mandates Reform Act Analyses

This chapter presents the analyses conducted in accordance with the Regulatory Flexibility Act and Unfunded Mandates Reform Act.

10.1. Regulatory Flexibility Act

The Regulatory Flexibility Act of 1980 (5 U.S.C §601 et seq.) requires agencies to evaluate the potential effects of their proposed and final rules on small businesses, small organizations, and small Government jurisdictions.

5 U.S.C §603 requires agencies to prepare and make available for public comments initial and final regulatory flexibility analysis (RFA) describing the impact of proposed and final rules on small entities, unless the head of an agency certifies the rulemaking will not have a significant economic impact on a substantial number of small entities. Agencies must also provide a statement of the factual basis for this certification.

The head of the agency has certified that this proposed rule would not have a significant economic impact on a substantial number of small entities. The factual basis for the certification (5 U.S.C. 605(b)) is explained below.

Although NHTSA is not required to issue an initial RFA, as a means of venting the issues and providing the basis for the certification, we discuss below the issues that an initial RFA would address (§604),

Section 603(b) of the Act specifies the content of an RFA. Each RFA 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 a proposed or final rule;
3. A description of and, where feasible, an estimate of the number of small entities to which

the proposed or final rule will apply;

4. A description of the projected reporting, recording keeping and other compliance requirements of a proposed or final 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 rule;

6. Each final RFA shall also contain a description of any significant alternatives to the proposed of final rule which accomplish the stated objectives of applicable status and which minimize any significant economic impact of the final on small entities.

<u>1. A description of the reasons why action by the agency is being considered.</u>
NHTSA is considering this action to improve the safety of pedestrians. In particular, this action aims to address the injury severity in regard to head injuries incurred to pedestrians as the result of being struck by a light vehicle. By setting the HIC requirement, this action ensures that passenger vehicles are designed to mitigate the risk of serious to fatal child and adult head injury in pedestrian crashes. NHTSA is also initiating this rulemaking as part of the agency's obligations under the 1998 Agreement. See Section IV of the NPRM preamble.

<u>2. A succinct statement of the objectives of, and legal basis for a proposed or final rule.</u>
NHTSA is proposing these changes under the authority of 49 U.S.C. 322, 30111, 30115, 30117, and 30666, as well as a delegation of authority at 49 CFR 1.95. The agency is authorized to issue Federal motor vehicle safety standards that meet the need for motor vehicle safety.

<u>3. A description of and, where feasible, an estimate of the number of small entities to which the NPRM would apply.</u>
The proposed rule would affect motor vehicle manufacturers and final stage manufacturers. To determine if there is a significant impact on small vehicle manufacturers, we have identified such

firms that exist currently.

Business entities are defined as small business using the North American Industry Classification System (NAICS) code, for the purpose of receiving Small Business Administration 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, light- and heavy-duty trucks, buses, motor homes, new tires, or motor vehicle body manufacturing, the firm must have fewer than 1,500 employees to be classified as a small business[36]. For alterers and final-stage manufacturers, the firm must have fewer than 500 employees to be classified as a small business.[37]

Currently, there are at least 12 small light vehicle manufacturers in the United States. [38] We do not believe the small manufacturers listed in the table are developing hood systems and/or related hardware for installation on the vehicles they manufacture. In today's motor vehicle market, small vehicle manufacturers, who are less able than large manufacturers to take advantage of economies of scale to lower production costs, typically produce specialized, expensive vehicles and could obtain the hoods from a supplier (a large entity). Nonetheless, regardless of whether small manufacturers turn to a supplier, this NPRM proposes a performance requirement that can be met using a simple headform test. There is no crash testing of vehicles. The vehicle manufacturer would be able to certify its vehicles to FMVSS No. 228 through the use of energy-absorbing structures and strategic layout of hard engine components vis-a-vis the hood surface.

[36] See NAICS codes 336110 (Automobile and Light Duty Motor Vehicle Manufacturing) and 336120 (Heavy Duty Truck Manufacturing) https://www.sba.gov/sites/sbagov/files/2023-06/Table%20of%20Size%20Standards_Effective%20March%2017%2C%202023%20%282%29.pdf

[37] See NAICS code 336211 (Motor Vehicle Body Manufacturing) https://www.sba.gov/sites/sbagov/files/2023-06/Table%20of%20Size%20Standards_Effective%20March%2017%2C%202023%20%282%29.pdf

[38] *Classified in NAICS under Subsector 336—Transportation Equipment Manufacturing for Automobile and Light Duty Motor Vehicle Manufacturing (336110) and Heavy Duty Truck Manufacturing (336120). Available at: https://www.sba.gov/document/support--table-size-standards.*

The test specified in the standard for certifying the vehicle is straightforward and easy to perform; designing and manufacturing a compliant hood is relatively uncomplicated. Small vehicle manufacturers encounter vastly more complicated testing requirements when currently certifying their vehicles, such as crash testing with test dummies. This proposed rule would not have significant impact on the manufacturers.

Table 129 provides information about the 12 small volume domestic manufacturers in MY 2020. All are small manufacturers, having fewer than 1,500 employees. We do not believe the small manufacturers listed in the table are developing hood systems and/or related hardware for installation on the vehicles they manufacture. In today's motor vehicle market, small vehicle manufacturers, who are less able than large manufacturers to take advantage of economies of scale to lower production costs, typically produce specialized, expensive vehicles and could obtain the hoods from a supplier (a large entity). Nonetheless, regardless of whether small manufacturers turn to a supplier, this NPRM proposes a performance requirement that can be met using a simple headform test. There is no crash testing of vehicles. The vehicle manufacturer would be able to certify its vehicles to FMVSS No. 228 through the use of energy-absorbing structures and strategic layout of hard engine components vis-a-vis the hood surface.

The test specified in the standard for certifying the vehicle is straightforward and easy to perform; designing and manufacturing a compliant hood is relatively uncomplicated. Small vehicle manufacturers encounter vastly more complicated testing requirements when currently certifying their vehicles, such as crash testing with test dummies. This proposed rule would not have significant impact on the manufacturers.

Table 129: Small Volume Vehicle Manufacturers (MY 2020)[39]

Manufacturer	Type of Vehicles	Number of Employees (Appx.)	MSRP for Vehicles (Appx.)
Anteros Coachworks	Specialty Sports Cars	2	$110,000
Callaway Cars	Specialty Sports Cars	50	~$17,000 above base (GM) vehicle price
Carroll Shelby International	Specialty Sports Cars	170	$86,085-$180,995+
Equus Automotive	Specialty Sports Cars	25	$250,000+
Falcon Motorsports	Specialty Sports Cars	2	$300,000-$400,000
Faraday Future	Electric	350	$225,000
Fisker Inc.	Electric	<200	$37,499+
Karma Automotive	Electric	750	$135,000
Panoz	Specialty Sports Cars	<50	$159,900+
Rossion Automotive	Specialty Sports Cars	70	$80,000
Saleen Automotive	Specialty Sports Cars	170	$48,000-$100,000+
SSC North America	Specialty Sports Cars	9	$2,000,000

Furthermore, there are a significant number (several hundred) of final-stage manufacturers and alterers that could be impacted by the proposed rule. These manufacturers buy incomplete vehicles from the first-stage vehicle manufacturers or complete vehicles that they alter before first sale, respectively. Many of these vehicles are van conversions, but there are a variety of vehicles affected. These final-stage manufacturers would likely meet the standard by passing on the compliance by the first-stage vehicle manufacturer. Alterers would likely refrain from modifying the hood, which allows them to pass on the compliance by the original manufacturer

[39] Provided to illustrate the current population of small vehicle manufacturers.

of the vehicle the small entity is altering. Thus, while there are a substantial number of final stage manufacturers and alterers potentially impacted by the proposed rule, we do not believe the proposed rule will have a significant economic impact on the entities. Either a pass-through certification process will apply to these manufacturers, or they will do the work themselves to certify the vehicle.

4. A description of the projected reporting, record keeping and other compliance requirements of a final 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.

The proposed rule does not create any new reporting or recordkeeping requirements, nor does it affect any existing reporting or recordkeeping requirements. Furthermore, there are no expected compliance impacts for small businesses beyond any incremental costs associated with the countermeasures employed to meet the requirements specified in the proposed rule. Manufacturers would have to self-certify the compliance of their vehicles with the new FMVSS No. 228, but they currently self-certify the compliance of their vehicles to a host of Federal motor vehicle safety standards, many of which are much more complex than the standard proposed by this NPRM. Moreover, the burden and cost of certifying to proposed FMVSS No. 228 is relatively small. The performance test is done with an impactor without crash testing the vehicles, and multiple impacts can be performed on a single hood to assess conformance. The vehicle manufacturer is not required by the FMVSS to test every point on the hood; instead, it only must ensure that the hood will meet FMVSS No. 228 when tested by NHTSA in an agency compliance test. Thus, the small manufacturer, knowing its vehicle, can identify the part of the hood least likely to meet the standard and can focus its testing there. If that part of the hood can be made to meet the standard, the small manufacturer can determine through engineering analyses and other means that other parts of the hood can meet the standard as well. This is to say, a small entity is not directed by the standard to test in any way. Small entities can easily base their certification on simple headform testing, straightforward engineering analyses, modeling, a combination of these, or other such means to certify to the proposed standard. Although a small entity is not required by NHTSA to test to self-certify compliance with proposed FMVSS No. 228, if they wish to perform the physical tests described in the proposed standard they could readily contract with an outside testing laboratory to conduct the headform impact tests in the proposal. (NHTSA itself has contracted with labs for such testing in the past.) The number of tests to be performed on a particular hood to certify compliance would be at the discretion of the manufacturer. However, because of the manufacturer's in-depth knowledge of its vehicle design, the symmetry of hood design and predictability of results, and the depth of engineering judgment and knowledge in this area, NHTSA believes it is reasonable that the number of necessary test points could be reduced to the locations with the least compliance margin. To illustrate, NHTSA in the past has assessed hood performance based on a test series of 10 impacts, at a total cost of approximately $8,000 for the 10 impacts. Because these impacts may involve more than a single hood, we would include an additional cost for hood parts, which results in an overall estimated testing cost of $10,000 for certification testing. This overall cost can then be amortized over the entire number of vehicles produced matching the test design. Thus, the amortized cost would not constitute a significant percentage of the relative cost of the vehicle. Comments are requested on these estimates.

As with large manufacturers, small manufacturers would self-certify compliance to FMVSS No. 228 by the same certification label now required for all applicable Federal motor vehicle safety standards. The label is placed on the vehicle, usually in the door jamb on light vehicles. NHTSA does not approve certification of vehicles before sale, so the proposed standard would have a minimal impact on small entities once they assure the compliance of the vehicle and so certify.

5. An identification, to the extent practicable, of all relevant Federal rules which may duplicate, overlap, or conflict with the final rule.

We know of no Federal rules which duplicate, overlap, or conflict with this proposed rule.

6.Each final RFA shall also contain a description of any significant alternatives to the final rule which accomplish the stated objectives of applicable statutes and which minimize any significant economic impact of the final on small entities.

In addition to the requirements included in this NPRM, the PRIA considered a less stringent regulatory alternative in which the requirements specified in the proposed rule would match the EU interpretation of GTR 9 and a more stringent alternative in which the requirements specified in the proposed rule would be applicable to the entire Hood Top, i.e., the Test Area would encompass the entire Hood Top. When comparing the less stringent regulatory alternative to the proposed rule, costs would be very similar and due to data limitations, are assumed to be the same. However, the proposed rule provides more benefits relative to the less stringent regulatory alternative. While the more stringent regulatory alternative would offer greater overall benefits, we were unable to estimate the cost for the more stringent regulatory alternative due to data limitations. Overall, the less stringent regulatory alternative and proposed rule are only associated with fuel economy costs incurred over the life span of the vehicles impacted. Due to uncertainty about the feasibility and costs associated with the more stringent regulatory alternative, this analysis was not able to assess the potential impacts of that regulatory alternative on small entities. While costs could increase with the more stringent regulatory alternative, it is not NHTSA's preferred alternative. If the agency decides the alternative should be further pursued, the agency will consider the impacts to small entities when determining whether to finalize.

We have identified no meaningful alternatives that both: (1) do not rely on the establishment of a

HIC requirement; and (2) are expected to achieve improvements in pedestrian safety consistent with those expected under the proposed rule. However, NHTSA is proposing to provide final-stage manufacturers and alterers an additional year of lead time for manufacturer certifications of compliance, in recognition of manufacturing differences between large and small manufacturers.[40] NHTSA anticipates that hood components and designs meeting FMVSS No. 228 may be developed by vehicle designers and suppliers and integrated into the fleets of larger vehicle manufacturers first, before small manufacturers. This NPRM recognizes this and proposes to provide smaller manufacturers more lead time to work with designers and suppliers after the demands of the larger manufacturers are met, without the small manufacturers having to cease production of their vehicles. Although, as discussed above, we do not project the proposed rule to have a significant economic impact on a substantial number of small entities, the additional lead time would provide flexibility to further minimize any impacts.

10.2. Unfunded Mandates Reform Act Analyses

The Unfunded Mandates Reform Act of 1995 (UMRA) (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 States, 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 2021 results in $165 million (2021 index value of 270.97 / 1995 index value of 152.40 = 1.78[41]). This proposed rule would not result in a cost of $178 million or more in any one year to either State, local, or tribal governments, in the aggregate, or the private sector. Thus, this proposed rule is not subject to the requirements of

[40] This approach accords with 49 CFR 571.8(b).

[41] Consumer Price Index Data from 1913 to 2023 (usinflationcalculator.com)

sections 202 of the UMRA.

11. References

Blincoe, L., Miller, T. R., Wang, J., Swedler, D., Coughlin, T., Lawrence, B., . . . Dingus, T. (2019). *The Economic and Societal Impact of Motor Vehicle Crashes.* Washington, D.C.: National Center for Statistics and Analysis, National Highway Traffic Safety Administration.

Davis, S. C., Diegel, S. W., & Boundy, R. G. (2021). Transportation energy data book: Edition 39. Retrieved from: https://tedb.ornl.gov/wp-content/uploads/2021/02/TEDB_Ed_39.pdf.

Hertz, E. (1993). *A Note on the Head Injury Criterion (HIC) as a Predictor of the Risk of Skull Fracture.* Washington, D.C.: National Highway Traffic Safety Administration.

Eppinger, R., Kleinberger, M., Kuppa, S., Saul, R., & Sun, E. (1999). *Development of Improved Injury Criteria for the Assessment of Advanced Automotive Restraint Systems.* Washington, D.C.: National Highway Traffic Safety Administration.

Mertz, H., Prasad, P., & Nusholtz, G. (1996). *Head Injury Risk Assessment for Forehead Impacts.* Washington, D.C.: SAE International .

NHTSA. (1996). *Pedestrian Crash Data Study, 1996 Data Collection, Coding, and Editing Manual.* National Center for Statistics and Analysis. Washington, D.C.: U.S. Department of Transportation. Retrieved from https://www.nhtsa.gov/file-downloads?p=nhtsa/downloads/Ped/

NHTSA. (2014). *Cost and Weight Analysis for Pedestrian Protection.* Waltonen Engineering, Inc. Contract Number: DTNH22-10-D-00194/0003. Washington, D.C.: Department of Transportation.

NHTSA. (2021). *Revised Departmental Guidance, Treatment of Value of Preventing Fatalities and Injuries in Preparing Economic Analyses*. March 2021. Washington, D.C.: Department of Transportation.

NHTSA (2023). *New Car Assessment Program.* Washington, D.C.: Department of Transportation.

NHTSA. (2023). *Federal Motor Vehicle Safety Standards; Hood Crashworthiness for Pedestrian Safety.* Washington, D.C.: Department of Transportation.

Stammen, J., Mallory, A. (2006). *Preliminary Assessment of Benefits Afforded by the Head Portion of the Pedestrian Global Technical Regulation (GTR)*. NHTSA Vehicle Research & Test Center, Transportation Research Center, Inc. Washington, D.C.: Department of Transportation.

Stammen, J., Mallory, A. (2007). *Pedestrian GTR Testing of Current Vehicles*. NHTSA Vehicle Research & Test Center, Transportation Research Center, Inc. Washington, D.C.: Department of Transportation.

United Nations Economic Commission for Europe, Transport: Vehicle Regulations; 1998 Agreement on Global Technical Regulations, Appendix to Global Technical Regulation No. 9 Pedestrian Safety (ECE/TRANS/180/Add.9/Appendix 1), Geneva, Switzerland, 2009.

United Nations Economic Commission for Europe. (2021). *Amendment 3 to UN Global Technical Regulation No. 9.* Geneva, Switzerland. Economic and Social Council.

U.S. Energy Information Administration - EIA - Independent Statistics and Analysis. *Annual Energy Outlook 2022 Table: Table 12. Petroleum and Other Liquids Prices*. https://www.eia.gov/outlooks/aeo/.

Wang, J.-S. (2023). *KABCO-to-MAIS Translators - 2022 Update.* Washington, DC: Naional Highway Traffic Safety Administration.

12. Appendix

12.1. Appendix A: Vehicle Miles Traveled and Survivability

This chapter presents the vehicle miles traveled (VMT), survivability schedule and discount adjustment for light vehicles. To accurately assess the impact of automotive fuel economy standards and safety standards, NHTSA uses vehicle survivability and vehicle mileage schedules by vehicle age. Vehicle survivability is defined as the share of vehicles remaining in the fleet at a given age. This measure is developed from the National Vehicle Population Profile (NVPP) complied by R.L. Polk & Company data on registered vehicles in use by model year across calendar years. The NVPP is an annual census of passenger cars and light trucks registered for on-road operation in the United States.

VMT by vehicle age is estimated based on a NHTSA longitudinal analysis of odometer readings for a large number of vehicles tracked by VIN over time. As the probability of being involved in a crash which results in fatalities and/or non-fatal injuries is a function of vehicle miles traveled, vehicle miles traveled are considered a proxy measure for safety benefits.

NHTSA uses the VMT and survivability schedules to estimate discount rates that serve the purpose of discounting future impacts realized over the course of a vehicle's lifetime to reflect their present value.

As the discount factor is specific to the discount rate, the present discount factor (PD) or raw discount factor is first established based on the discount rate. This is calculated by the following equation:

$$Present\ Discount\ Factor = \frac{1}{(1+i)^{N-\frac{1}{2}}}$$

Where *i* is the discount rate and *N* is the vehicle age in years.

The weighed discount factor, which is specific to the age of the vehicle, is then calculated by multiplying the PD by the percent of the total VMT that the vehicle travels in that specific year. The lifetime weighed present discount factor is then calculated as the sum of the weighted discount factor over the course of the vehicle's lifetime.

Table 130 and Table 131 present the discount factors at three and seven percent for passenger cars and light trucks, respectively. Lastly, Table 132 summarizes the light vehicle discount adjustment factors.

Table 130: Light Vehicle Passenger Car VMT

Year	RAW DISCOUNT FACTOR 3%	RAW DISCOUNT FACTOR 7%	Survival	Exposure	Aggregate Exposure	Exposure Proportion	Weighted Discount Factor 3%	Weighted Discount Factor 7%
1	99%	97%	1.0000	15,861	15,861	11%	**11%**	**11%**
2	96%	90%	0.9878	13,684	13,518	10%	**9%**	**9%**
3	93%	84%	0.9766	13,479	13,163	9%	**9%**	**8%**
4	90%	79%	0.9614	13,218	12,708	9%	**8%**	**7%**
5	88%	74%	0.9450	12,977	12,264	9%	**8%**	**6%**
6	85%	69%	0.9298	12,521	11,643	8%	**7%**	**6%**
7	83%	64%	0.9113	11,465	10,448	7%	**6%**	**5%**
8	80%	60%	0.8912	10,203	9,092	6%	**5%**	**4%**
9	78%	56%	0.8689	8,842	7,683	5%	**4%**	**3%**
10	76%	53%	0.8397	7,493	6,292	4%	**3%**	**2%**
11	73%	49%	0.7999	6,264	5,011	4%	**3%**	**2%**
12	71%	46%	0.7556	5,266	3,979	3%	**2%**	**1%**
13	69%	43%	0.7055	4,906	3,461	2%	**2%**	**1%**
14	67%	40%	0.6527	4,644	3,031	2%	**1%**	**1%**
15	65%	37%	0.5946	4,604	2,738	2%	**1%**	**1%**
16	63%	35%	0.5311	4,497	2,388	2%	**1%**	**1%**
17	61%	33%	0.4585	4,394	2,015	1%	**1%**	**0%**
18	60%	31%	0.3832	4,296	1,646	1%	**1%**	**0%**
19	58%	29%	0.3077	4,203	1,293	1%	**1%**	**0%**
20	56%	27%	0.2414	4,114	993	1%	**0%**	**0%**
21	55%	25%	0.1833	4,030	739	1%	**0%**	**0%**
22	53%	23%	0.1388	3,951	548	0%	**0%**	**0%**
23	51%	22%	0.1066	3,877	413	0%	**0%**	**0%**
24	50%	20%	0.0820	3,807	312	0%	**0%**	**0%**
25	48%	19%	0.0629	3,741	235	0%	**0%**	**0%**
26	47%	18%	0.0514	3,681	189	0%	**0%**	**0%**
27	46%	17%	0.0420	3,625	152	0%	**0%**	**0%**

28	44%	16%	0.0337	3,574	120	0%	**0%**	**0%**
29	43%	15%	0.0281	3,528	99	0%	**0%**	**0%**
30	42%	14%	0.0235	3,486	82	0%	**0%**	**0%**
31	41%	13%	0.0000	3,449	0	0%	**0%**	**0%**
32	39%	12%	0.0000	3,449	0	0%	**0%**	**0%**
33	38%	11%	0.0000	3,449	0	0%	**0%**	**0%**
34	37%	10%	0.0000	3,449	0	0%	**0%**	**0%**
35	36%	10%	0.0000	3,449	0	0%	**0%**	**0%**
36	35%	9%	0.0000	3,449	0	0%	**0%**	**0%**
37	34%	8%	0.0000	3,449	0	0%	**0%**	**0%**
38	33%	8%	0.0000	3,449	0	0%	**0%**	**0%**
39	32%	7%	0.0000	3,449	0	0%	**0%**	**0%**
40	31%	7%	0.0000	3,449	0	0%	**0%**	**0%**
Weighted Discount Factors for Passenger Cars at 3% and 7%							**0.8354**	**0.6816**

Table 131: Light Vehicle Survivability Schedule, Light Trucks

Year	**RAW DISCOUNT FACTOR 3%**	**RAW DISCOUNT FACTOR 7%**	**Survival**	**Exposure**	**Aggregate Exposure**	**Exposure Proportion**	**Weighted Discount Factor 3%**	**Weighted Discount Factor 7%**
1	99%	97%	1.0000	16,502	16,502	11%	**10%**	**10%**
2	96%	90%	0.9776	14,828	14,496	9%	**9%**	**8%**
3	93%	84%	0.9630	14,552	14,013	9%	**8%**	**8%**
4	90%	79%	0.9428	14,279	13,461	9%	**8%**	**7%**
5	88%	74%	0.9311	13,783	12,833	8%	**7%**	**6%**
6	85%	69%	0.9152	13,039	11,933	8%	**6%**	**5%**
7	83%	64%	0.8933	12,103	10,811	7%	**6%**	**4%**
8	80%	60%	0.8700	11,034	9,600	6%	**5%**	**4%**
9	78%	56%	0.8411	9,891	8,319	5%	**4%**	**3%**
10	76%	53%	0.7963	8,730	6,952	4%	**3%**	**2%**
11	73%	49%	0.7423	7,612	5,650	4%	**3%**	**2%**
12	71%	46%	0.6916	6,804	4,706	3%	**2%**	**1%**
13	69%	43%	0.6410	5,931	3,802	2%	**2%**	**1%**
14	67%	40%	0.5833	5,180	3,022	2%	**1%**	**1%**
15	65%	37%	0.5350	4,979	2,664	2%	**1%**	**1%**
16	63%	35%	0.4861	4,839	2,352	2%	**1%**	**1%**
17	61%	33%	0.4422	4,706	2,081	1%	**1%**	**0%**
18	60%	31%	0.3976	4,580	1,821	1%	**1%**	**0%**
19	58%	29%	0.3520	4,463	1,571	1%	**1%**	**0%**
20	56%	27%	0.3092	4,353	1,346	1%	**0%**	**0%**
21	55%	25%	0.2666	4,252	1,134	1%	**0%**	**0%**
22	53%	23%	0.2278	4,158	947	1%	**0%**	**0%**
23	51%	22%	0.2019	4,071	822	1%	**0%**	**0%**

24	50%	20%	0.1750	3,993	699	0%	**0%**	**0%**
25	48%	19%	0.1584	3,922	621	0%	**0%**	**0%**
26	47%	18%	0.1452	3,860	560	0%	**0%**	**0%**
27	46%	17%	0.1390	3,805	529	0%	**0%**	**0%**
28	44%	16%	0.1250	3,758	470	0%	**0%**	**0%**
29	43%	15%	0.1112	3,718	413	0%	**0%**	**0%**
30	42%	14%	0.1028	3,687	379	0%	**0%**	**0%**
31	41%	13%	0.0933	3,660	341	0%	**0%**	**0%**
32	39%	12%	0.0835	3,660	305	0%	**0%**	**0%**
33	38%	11%	0.0731	3,660	267	0%	**0%**	**0%**
34	37%	10%	0.0619	3,660	227	0%	**0%**	**0%**
35	36%	10%	0.0502	3,660	184	0%	**0%**	**0%**
36	35%	9%	0.0384	3,660	141	0%	**0%**	**0%**
37	34%	8%	0.0273	3,660	100	0%	**0%**	**0%**
38	33%	8%	0.0000	3,660	0	0%	**0%**	**0%**
39	32%	7%	0.0000	3,660	0	0%	**0%**	**0%**
40	31%	7%	0.0000	3,660	0	0%	**0%**	**0%**
Weighted Discount Factors for Light Trucks at 3% and 7%							**0.8216**	**0.6626**

Table 132: Light Vehicle Discount Adjustment Factors

Vehicle Type	**3%**	**7%**
Passenger Car	0.8354	0.6816
Light Trucks	0.8216	0.6626

12.2. Appendix B: Model Year and Calendar Year Comparison

In order to compare benefits and costs, cost-effectiveness and benefit-cost analyses consider the benefits and costs associated with a specific model year (MY). The costs associated with a specific MY are often incurred in the year that the vehicle is manufactured, while the benefits associated with the proposed rule occur over the course of the vehicle MY's lifetime. Benefits occurring over the course of the vehicle MY's lifetime are discounted in order to compare their present value to the costs incurred in the first year that the vehicle is manufactured. Although the cost-effectiveness and benefit-cost analyses consider the impacts of the proposed rule specific to a particular MY, those benefits and costs also represent the annual benefits and costs for a specific calendar year (CY) when all applicable light vehicles are in compliance with a rule. In support of that statement, the following discussion presents the calculation of benefits for a specific MY and the annual average for a CY when applicable vehicles are in compliance with a rule.

This analysis makes use of the VMT for a passenger car over the course of a 30 year lifespan. Furthermore, we also assume that for a specific vehicle the probability of being involved in a crash which results in fatalities and/or non-fatal injuries is a function of vehicle miles traveled. Therefore, vehicle miles traveled are considered a proxy measure for safety benefits. In the following two examples, the figures use the same data (Figure 11/Figure 13and Figure 12/Figure 14). We first present the calculation of benefit for a specific model year.

Figure 11 presents the vehicle miles traveled by age of vehicle. The lifetime vehicle miles travelled of a particular MY reflect the sum of miles traveled across the 30 years for which that vehicle is on the road. For the purpose of this analysis, we selected three years to focus on for presentation purposes. The first column in blue presents the vehicle miles traveled over the course of the first year that a vehicle is on the road. The column in red presents the vehicle miles traveled over the course of the fifth year that a vehicle is on the road. The column in purple presents the vehicle miles traveled over the course of the tenth year that a vehicle is on the road.

Figure 11: Vehicle Miles Traveled by Age of Vehicle

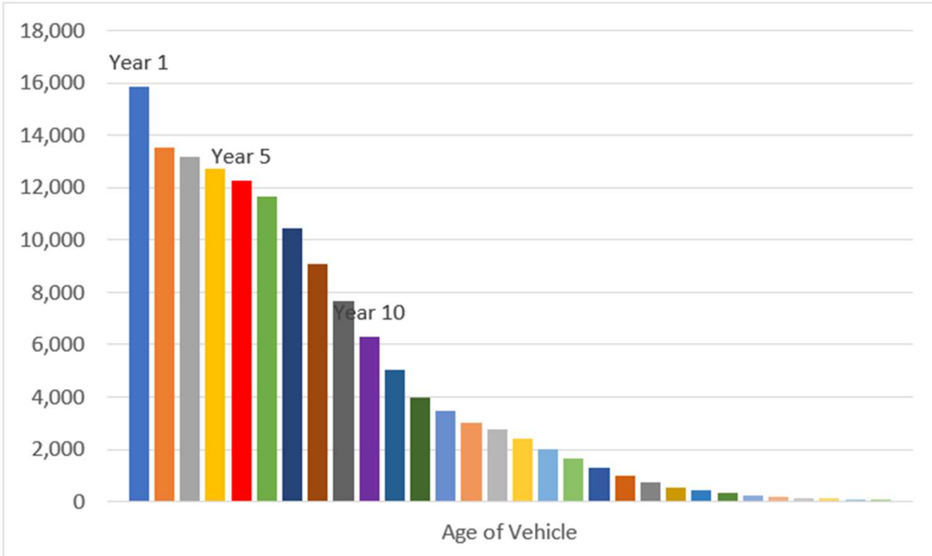
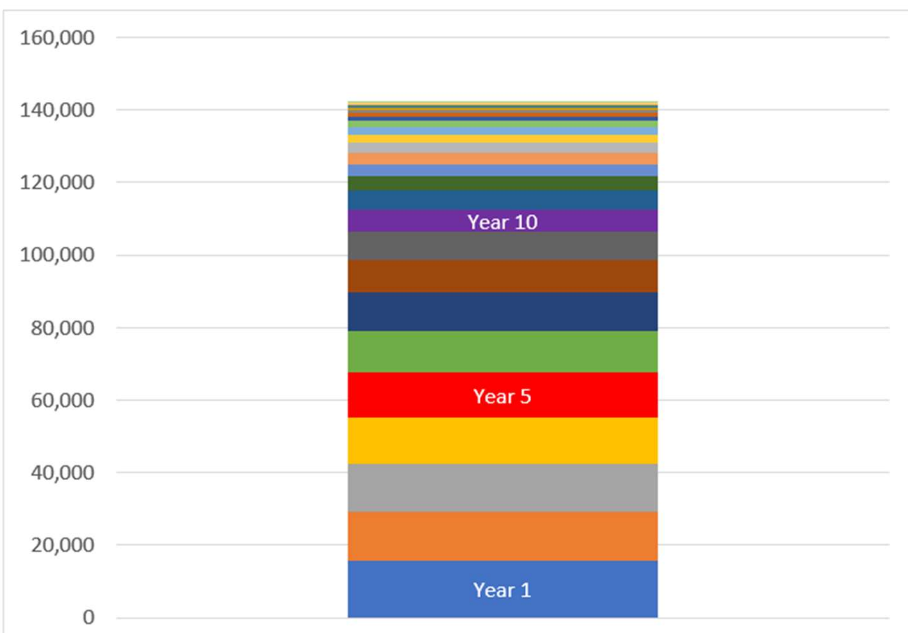


Figure 12 presents the total vehicle miles traveled over the course of a vehicle's lifetime. We note that this figure is just a summation of the columns presented in the previous table.

Figure 12: Total Lifetime Miles Traveled



Therefore, the calculation of lifetime of undiscounted benefits for a particular MY are presented in equation (2):

$$Lifetime\ Safety\ Benefits\ (LSB)\ for\ MY = \sum_{i=1}^{30} Safety\ Benefits_i \qquad (2).$$

Where i is the year.

Equation (2) shows that the lifetime safety benefits for a particular MY are the sum of safety benefits occurring in each year which that vehicle is on the road over its 30 year lifespan.

For simplicity, we consider a MY 2020 vehicle whose undiscounted lifetime safety benefits would be presented as:

$$LSB_{MY\ 2020} = Safety\ Benefit_{2020} + Safety\ Benefit_{2021} \ldots Safety\ Benefit_{2050}\ (3).$$

In Equation (3), we see that the lifetime safety benefits are the sum of safety benefits across the lifespan of this vehicle which would be realized those from 2020 (year 1) through 2050 (year 30). Furthermore, we consider that safety benefits realized between 2020 and 2021 can also be labeled as the safety benefits realized over the first year the vehicle is on the road, which we can refer to as year 1.

We now consider the case in which benefits and costs are considered on a CY basis for 2020. Figure 13 presents the annual average number of vehicle miles traveled for a given calendar year by vehicle age. The average number of vehicle miles traveled for a particular CY reflect the sum of miles traveled across the vehicle is on the road during that CY. Similarly, we highlight three of the columns in the figure. The first column in blue presents the vehicle miles traveled for vehicles in their first CY year of the road. The column in red presents the vehicle miles traveled over the course of a CY for vehicles who are five years old. The column in purple presents the vehicle miles traveled over the course of a CY for vehicles who are ten years old.

Figure 13: Average Annual Vehicle Miles Traveled in a Calendar Year by Vehicle Age in 2020

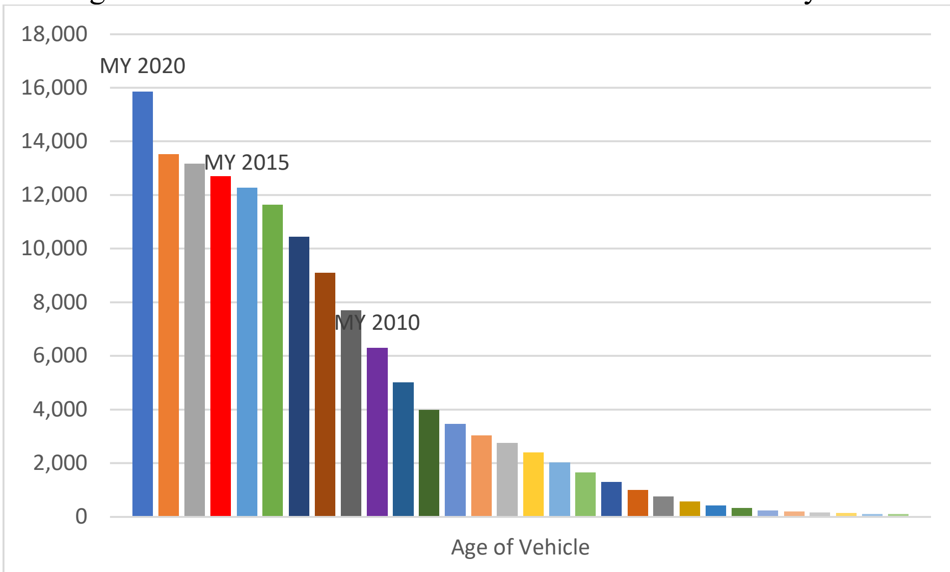


Figure 14 presents the total annual average miles traveled in a calendar year across all vehicles on the road. We note that this figure is just a summation of the columns presented in the previous table.

Figure 14: Total Annual Average Vehicle Miles Traveled in a Calendar Year

Equation (4) presents the calculation of the average annual safety benefits for a CY when all vehicles are in compliance with the proposed rule, which would happen about 32 years after the rule is published if the lead time is taken into account.

$$Average\ Annual\ Safety\ Benefits\ (AASB) for\ CY = \sum_{n=1}^{30} Safety\ Benefits_n \text{ (4).}$$

Where *n* represents the vehicle's number of years on the road.

The annual average safety benefits for a given calendar year are the sum of safety benefits from all vehicles on the road that year. Therefore, for example, the average annual safety benefits for the CY 2020 would be defined as:

$$AASB_{CY\ 2020} = Safety\ Benefit_{Year\ 1} + Safety\ Benefit_{Year\ 2} \ldots Safety\ Benefit_{Year\ 30} \text{ (5).}$$

In equation (5), we see that the annual average safety benefits are the sum of the safety benefits for all vehicles on the road across the lifespan of 30 years. That is, it is the sum of safety benefits for those vehicles who are brand new (year 1), second year on the road, up to those in their last year on the road (year 30). Similar to the earlier example, for MY 2020 vehicles, the safety benefits for year 1 could also be labeled as the safety benefits realized between 2020 and 2021. Additionally, we include the following hypothetical example in Table 133 that demonstrates the two approaches. For simplicity, consider a MY 2020 vehicle that is first driven in 2021 and that vehicles have an average lifespan of ten years. In the first year that the vehicle is on the road (2021), the hypothetical countermeasures on the vehicle prevent ten fatalities. Based on the vehicle miles traveled, in each following year that number of fatalities prevented will decrease by one. Therefore, in the second year that the vehicle is on the road (2022), the hypothetical countermeasure will prevent nine fatalities, in the third year it would prevent eight fatalities, and so on. The undiscounted stream of benefits over the course of the 2020 MY vehicle is highlighted in green. Furthermore, at the bottom of the column, the sum of undiscounted benefits for MY 2020 across the ten year life span is 55 fatalities prevented. On the other hand, we consider all of the vehicles on the road in 2030 which is the first CY in which all vehicles would be in compliance. Totaling across the MY 2020 through MY 2029 vehicles on the road that year, we again get a total of undiscounted benefit of 55 fatalities prevented which is highlighted in blue. Comparing the blue row with the green column indicates how these two approaches mirror each other once all vehicles are in compliance.

Table 133: Hypothetical Example of Benefits Stream by MY and CY

CY	**MY**										
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	
2021	10										
2022	9	10									
2023	8	9	10								
2024	7	8	9	10							
2025	6	7	8	9	10						
2026	5	6	7	8	9	10					
2027	4	5	6	7	8	9	10				
2028	3	4	5	6	7	8	9	10			
2029	2	3	4	5	6	7	8	9	10		Total
2030	1	2	3	4	5	6	7	8	9	10	**55**
Total	**55**	1	2	3	4	5	6	7	8	9	
			1	2	3	4	5	6	7	8	9

We note that there are alternate ways to address costs and benefits, such as presenting streams of future impacts on a calendar year basis. However, annual results from such analyses disassociate costs from the benefits that they enable. Discounting the value of future model year safety impacts to the purchase of the model year fleet retains the link between costs and the benefits they actually produce. That is, the model year approach allows the costs for a given cohort of vehicles to be compared to the entirety of the benefits that cohort generates. By contrast, calendar year discounting compares cost and benefit streams that are unrelated. Each calendar years costs compare to a subset of the actual benefits associated with those costs, and, over time, to benefits that accrue from multiple years costs. In other words, the costs in any given year are associated with benefits unrelated to those costs. There is no direct link between these annual impacts. For this reason, NHTSA conducts model year analysis for policy decisions that are linked to consumer expenditures. While the calendar year method facilitates comparability to the types of regulations that generate streams of costs and benefits that occur on an annual basis, that approach will not accurately account for benefits, particularly for vehicle cohorts produced at the end of the policy horizon.

12.3. Appendix C: Comprehensive Costs

Comprehensive Costs and Relative Value Factors Reflecting $11.6 Million VSL. Please note the "Injury Subtotal" line should be used to value crashworthiness countermeasures. All unit costs are "per injured/killed person". PDO costs are per property damaged only vehicle. In addition, because lost after- tax market and household productivity are separate line items that are implicitly included in QALYs, the QALY values are reduced by these values so that the separate components can be added to produce the total comprehensive cost for each injury severity level.

Table 134: Comprehensive Costs in 2020 Dollars

Category	PDO	MAIS 0	MAIS 1	MAIS 2	MAIS 3	MAIS 4	MAIS 5	Fatal
Medical	$0	$0	$3,739	$15,299	$64,947	$182,093	$513,315	$15,117
EMS	$71	$45	$129	$264	$496	$999	$1,020	$1,076
Market Prod	$0	$0	$3,424	$24,318	$80,820	$176,891	$424,096	$1,172,349
Household Prod	$75	$57	$1,083	$8,926	$28,500	$47,158	$119,849	$364,180
Ins. Adm.	$228	$171	$3,933	$5,557	$18,332	$33,666	$86,497	$33,778
Workplace	$78	$58	$428	$3,321	$7,256	$7,991	$13,932	$14,802
Legal	$0	$0	$1,410	$3,997	$14,791	$31,806	$98,644	$127,003
Congestion	$2,643	$1,779	$1,791	$1,822	$1,872	$1,899	$1,921	$7,186
Property Damage	$4,293	$3,211	$9,492	$10,149	$19,114	$19,474	$18,000	$13,372
QALYs	$0	$0	$30,606	$479,493	$1,071,207	$2,713,724	$6,049,769	$10,201,971
New Comprehensive Costs	$7,388	$5,321	$56,035	$553,146	$1,307,335	$3,215,701	$7,327,043	$11,950,834
Injury Subtotal	$452	$331	$44,752	$541,175	$1,286,349	$3,194,328	$7,307,122	$11,930,276
QALY Relatives	0.0000	0.0000	0.0030	0.0470	0.1050	0.2660	0.5930	1.0000
Comprehensive Relatives (Crash Avoidance)	0.0006	0.0004	0.0047	0.0463	0.1094	0.2691	0.6131	1.0000
Comprehensive Relatives (Crashworthiness)	0.0000	0.0000	0.0038	0.0454	0.1078	0.2677	0.6125	1.0000

Source: Blincoe, L. J., Miller, T. R., Zaloshnja, E., & Lawrence, B. A. (2014, May), The economic and societal impact of motor vehicle crashes, 2010 (Report No. DOT HS 812 013), Washington, DC: National Highway Traffic Safety Administration, Revised 2015. Values in the report were inflated from 2010 dollars to 2020 dollars.

12.4. Appendix D: Weight Impacts on Fuel Economy

Table 135: Summary of Weight Impacts on Fuel Economy

Category		Passenger Cars	LTVs
Baseline	Weight	3,288 lbs.	4,354 lbs.
	Fuel Economy	24.2 mpg	17.5 mpg
Proposed Rule	Weight	3,289 lbs.	4,355 lbs.
	Fuel Economy	24.19411353 mpg	17.49678523 mpg

Table 136: Calculation of Incremental Fuel Economy Costs for Passenger Cars

Year	Survivability	Exposure	Aggregate Exposure	Price per gallon minus taxes	Gallons with Base fuel economy	Gallons with new fuel economy	Baseline cost	New Fuel Economy Cost	Difference
1	1	15,861	15,861	$2.378	655.413	655.573	$1,558.52	$1,558.90	$0.38
2	0.9878	13,684	13,518	$2.421	558.595	558.731	$1,352.63	$1,352.96	$0.33
3	0.9766	13,479	13,163	$2.457	543.926	544.058	$1,336.38	$1,336.70	$0.33
4	0.9614	13,218	12,708	$2.552	525.124	525.252	$1,339.94	$1,340.27	$0.33
5	0.945	12,977	12,264	$2.656	506.777	506.900	$1,345.80	$1,346.12	$0.33
6	0.9298	12,521	11,643	$2.761	481.116	481.233	$1,328.50	$1,328.83	$0.32
7	0.9113	11,465	10,448	$2.858	431.736	431.841	$1,233.92	$1,234.22	$0.30
8	0.8912	10,203	9,092	$3.010	375.702	375.794	$1,130.78	$1,131.06	$0.28
9	0.8689	8,842	7,683	$3.192	317.479	317.557	$1,013.51	$1,013.75	$0.25
10	0.8397	7,493	6,292	$3.305	260.000	260.063	$859.24	$859.45	$0.21
11	0.7999	6,264	5,011	$3.414	207.066	207.116	$706.85	$707.02	$0.17
12	0.7556	5,266	3,979	$3.525	164.421	164.461	$579.52	$579.66	$0.14
13	0.7055	4,906	3,461	$3.623	143.017	143.051	$518.10	$518.23	$0.13
14	0.6527	4,644	3,031	$3.737	125.248	125.278	$468.00	$468.11	$0.11
15	0.5946	4,604	2,738	$3.851	113.140	113.168	$435.66	$435.76	$0.11
16	0.5311	4,497	2,388	$3.988	98.678	98.702	$393.55	$393.64	$0.10

17	0.4585	4,394	2,015	$4.084	83.264	83.285	$340.07	$340.16	$0.08
18	0.3832	4,296	1,646	$4.218	68.017	68.033	$286.87	$286.94	$0.07
19	0.3077	4,203	1,293	$4.348	53.430	53.443	$232.32	$232.38	$0.06
20	0.2414	4,114	993	$4.461	41.033	41.043	$183.03	$183.07	$0.04
21	0.1833	4,030	739	$4.617	30.537	30.545	$140.98	$141.01	$0.03
22	0.1388	3,951	548	$4.775	22.645	22.650	$108.13	$108.16	$0.03
23	0.1066	3,877	413	$4.906	17.066	17.070	$83.72	$83.74	$0.02
24	0.082	3,807	312	$5.066	12.893	12.896	$65.31	$65.33	$0.02
25	0.0629	3,741	235	$5.204	9.711	9.713	$50.53	$50.55	$0.01
26	0.0514	3,681	189	$5.313	7.810	7.812	$41.50	$41.51	$0.01
27	0.042	3,625	152	$5.444	6.281	6.283	$34.20	$34.20	$0.01
28	0.0337	3,574	120	$5.573	4.959	4.960	$27.64	$27.64	$0.01
29	0.0281	3,528	99	$5.714	4.091	4.092	$23.38	$23.38	$0.01
30	0.0235	3,486	82	$5.858	3.388	3.389	$19.85	$19.85	$0.00
31	0	3,449	0	$6.005	0.000	0.000	$0.00	$0.00	$0.00
32	0	3,449	0	$6.156	0.000	0.000	$0.00	$0.00	$0.00
33	0	3,449	0	$6.310	0.000	0.000	$0.00	$0.00	$0.00
34	0	3,449	0	$6.469	0.000	0.000	$0.00	$0.00	$0.00
35	0	3,449	0	$6.631	0.000	0.000	$0.00	$0.00	$0.00
36	0	3,449	0	$6.797	0.000	0.000	$0.00	$0.00	$0.00
37	0	3,449	0	$6.966	0.000	0.000	$0.00	$0.00	$0.00
38	0	3,449	0	$7.140	0.000	0.000	$0.00	$0.00	$0.00
39	0	3,449	0	$7.318	0.000	0.000	$0.00	$0.00	$0.00
40	0	3,449	0	$7.501	0.000	0.000	$0.00	$0.00	$0.00
Total		**238,721**	**142,116**				**$17,238.42**	**$17,242.61**	**$4.19**

Table 137: Calculation of Incremental Fuel Economy Costs for Passenger Cars

Year	Survivability	Exposure	Aggregate Exposure	Price per gallon minus taxes	Gallons with Base fuel economy	Gallons with new fuel economy	Baseline cost	New Fuel Economy Cost	Difference
1	1	16,502	16,502	$2.378	942.971	943.145	$2,242.31	$2,242.73	$0.41
2	0.9776	14,828	14,496	$2.421	828.343	828.495	$2,005.82	$2,006.19	$0.37
3	0.963	14,552	14,013	$2.457	800.743	800.890	$1,967.35	$1,967.71	$0.36
4	0.9428	14,279	13,461	$2.552	769.200	769.341	$1,962.74	$1,963.10	$0.36
5	0.9311	13,783	12,833	$2.656	733.314	733.449	$1,947.39	$1,947.75	$0.36
6	0.9152	13,039	11,933	$2.761	681.886	682.011	$1,882.89	$1,883.24	$0.35
7	0.8933	12,103	10,811	$2.858	617.771	617.885	$1,765.62	$1,765.94	$0.32
8	0.87	11,034	9,600	$3.010	548.571	548.672	$1,651.08	$1,651.38	$0.30
9	0.8411	9,891	8,319	$3.192	475.371	475.459	$1,517.55	$1,517.83	$0.28
10	0.7963	8,730	6,952	$3.305	397.257	397.330	$1,312.84	$1,313.08	$0.24
11	0.7423	7,612	5,650	$3.414	322.857	322.916	$1,102.12	$1,102.32	$0.20
12	0.6916	6,804	4,706	$3.525	268.914	268.964	$947.81	$947.99	$0.17
13	0.641	5,931	3,802	$3.623	217.257	217.297	$787.05	$787.19	$0.14
14	0.5833	5,180	3,022	$3.737	172.686	172.717	$645.26	$645.37	$0.12
15	0.535	4,979	2,664	$3.851	152.229	152.257	$586.17	$586.28	$0.11
16	0.4861	4,839	2,352	$3.988	134.400	134.425	$536.02	$536.12	$0.10
17	0.4422	4,706	2,081	$4.084	118.914	118.936	$485.68	$485.77	$0.09
18	0.3976	4,580	1,821	$4.218	104.057	104.076	$438.87	$438.95	$0.08
19	0.352	4,463	1,571	$4.348	89.771	89.788	$390.34	$390.41	$0.07
20	0.3092	4,353	1,346	$4.461	76.914	76.928	$343.08	$343.14	$0.06
21	0.2666	4,252	1,134	$4.617	64.800	64.812	$299.16	$299.21	$0.05
22	0.2278	4,158	947	$4.775	54.114	54.124	$258.40	$258.45	$0.05
23	0.2019	4,071	822	$4.906	46.971	46.980	$230.43	$230.48	$0.04
24	0.175	3,993	699	$5.066	39.943	39.950	$202.35	$202.39	$0.04

25	0.1584	3,922	621	$5.204	35.486	35.492	$184.67	$184.70	$0.03
26	0.1452	3,860	560	$5.313	32.000	32.006	$170.03	$170.06	$0.03
27	0.139	3,805	529	$5.444	30.229	30.234	$164.57	$164.60	$0.03
28	0.125	3,758	470	$5.573	26.857	26.862	$149.69	$149.71	$0.03
29	0.1112	3,718	413	$5.714	23.600	23.604	$134.85	$134.87	$0.02
30	0.1028	3,687	379	$5.858	21.657	21.661	$126.86	$126.89	$0.02
31	0.0933	3,660	341	$6.005	19.486	19.489	$117.01	$117.04	$0.02
32	0.0835	3,660	305	$6.156	17.429	17.432	$107.29	$107.31	$0.02
33	0.0731	3,660	267	$6.310	15.257	15.260	$96.28	$96.30	$0.02
34	0.0619	3,660	227	$6.469	12.971	12.974	$83.91	$83.92	$0.02
35	0.0502	3,660	184	$6.631	10.514	10.516	$69.72	$69.73	$0.01
36	0.0384	3,660	141	$6.797	8.057	8.059	$54.76	$54.77	$0.01
37	0.0273	3,660	100	$6.966	5.714	5.715	$39.81	$39.82	$0.01
38	0	3,660	0	$7.140	0.000	0.000	$0.00	$0.00	$0.00
39	0	3,660	0	$7.318	0.000	0.000	$0.00	$0.00	$0.00
40	0	3,660	0	$7.501	0.000	0.000	$0.00	$0.00	$0.00
Total		**258,012**	**156,074**		**8,918.514**	**8,920.153**	**$27,007.79**	**$27,012.75**	**$4.96**

12.5. Appendix E: Test Area-Hood Top Ratios

The target population consists of crashes in which the pedestrian MAIS injury is caused by contact with the Hood Top. However, since the Test Area is smaller than the Hood Top, we adjust the target population to account for the likelihood that a pedestrian-Hood Top crash impact occurs within the Test Area. We do so by discounting the target population by the average Test Area-Hood Top ratio for vehicles used in the analysis, separated by passenger cars and LTV. These ratios are provided in Table 138 and Table 139 respectively.

Table 138: Test Area - Hood Top Ratios (Passenger Cars)

Year	**Make**	**Hood Top***	**Test Area**	**Test Area/Hood Top**
2017	Audi A4	33,238	23,582	0.709
2010	Buick La Crosse	23,528	18,381	0.781
2018	Buick Regal	28,931	17,287	0.598
2017	Cadillac ATS	38,625	25,721	0.666
2016	Chevrolet Malibu	25,300	16,615	0.657
2016	Chevrolet Malibu Premier	19,431	13,278	0.683
2003	Ford Crown Victoria	38,609	28,939	0.750
2011	Ford Focus	34,836	22,050	0.633
2001	Honda Civic	8,162	4,314	0.529
1994	Honda Civic	14,185	8,386	0.591
2016	Honda Fit	16,290	9,133	0.561
2010	Kia Forte	19,444	10,379	0.534
2003	Toyota Camry	32,662	21,651	0.663
2016	Toyota Prius	21,532	9,920	0.461
2021	Volkswagen Arteon	28,248	17,261	0.611
2006	Volkswagen Passat	19,787	13,245	0.669
Average		**25,176**	**16,259**	**0.631**

*Areas measured as pixel counts using ImageJ software

Table 139: Test Area – Hood Top Ratios (LTV)

Year	Make	Hood Top	Test Area	Test Area/Hood Top
2010	Acura MDX	20,202	14,786	0.732
2006	Chevrolet Silverado	20,231	13,856	0.685
2016	Chevrolet Tahoe	25,869	21,011	0.812
1999	Dodge Dakota	26,251	21,500	0.819
2006	Dodge Durango	26,867	20,960	0.780
2003	Dodge Ram	24,061	17,545	0.729
2003	Ford E350	16,350	11,919	0.729
2016	Ford Edge	27,578	22,114	0.802
2001	Ford Escape	36,485	29,055	0.796
2015	Ford F150	25,609	21,202	0.828
2011	Ford Ranger	8,866	6,903	0.779
2004	GMC Savana	3,450	2,265	0.657
2005	Honda CRV	18,297	13,082	0.715
2011	Honda Odyssey	19,456	13,332	0.685
2003	Hummer H2	29,993	19,164	0.639
2011	Hyundai Tucson	20,151	15,389	0.764
2011	Jeep Cherokee	26,560	20,874	0.786
2002	Jeep Wrangler	21,927	14,372	0.655
2016	Nissan Rogue	14,059	10,333	0.735
2020	Subaru Outback	13,186	9,850	0.747
2003	Toyota 4Runner	23,590	18,459	0.782
2016	Toyota Sienna	23,627	18,103	0.766
2004	Toyota Sienna	18,710	13,965	0.746
2006	Toyota Tacoma	26,086	20,442	0.784
Average		**21,561**	**16,270**	**0.748**

*Areas measured as pixel counts using ImageJ software

12.6. Appendix F: Percent Change in Probability Calculations

To illustrate how percentage changes in probability of fatality and non-fatal injuries are calculated, Figure 15 shows hood overlays for one vehicle used in testing (2003 Crown Victoria). In this figure the Hood Area is a combination of the blue, purple, green and red areas. The Test Area is a combination of the purple, green and red areas. The three regulatory options considered are summarized in Table 71. The innermost area in Figure 15 (red area) shows the HIC1000 area under regulatory alternative #1, the less stringent option matching the EU interpretation of GTR 9 (GTR 9 Amendment 3). That area is two-thirds of the Test Area. The remaining one-third of the Test Area is HIC1700 area (a combination of the purple and green areas). Under the proposed regulatory alternative #2, the second innermost area, inclusive of the alternative #1 HIC1000 area, is the HIC1000 area for the proposal (a combination of the red and green areas). The remaining Test Arear is HIC1700 area (purple). A similar hood overlay for regulatory alternative #3. In Figure 16 below the Hood Top is a combination of the purple and green areas. The HIC1000 area is two-thirds of the Hood Top, shown in green in Table 15. The remaining one-third of the Hood Top is HIC1700 area (purple area). Similar overlays were created for all vehicles used in testing. Baseline probabilities of MAIS 1-5 plus fatality were established as an average probability of MAIS 1-5 plus fatality with test data HIC values. This is shown in Table 140.

Figure 15: Hood Overlay for 2003 Ford Crown Victoria

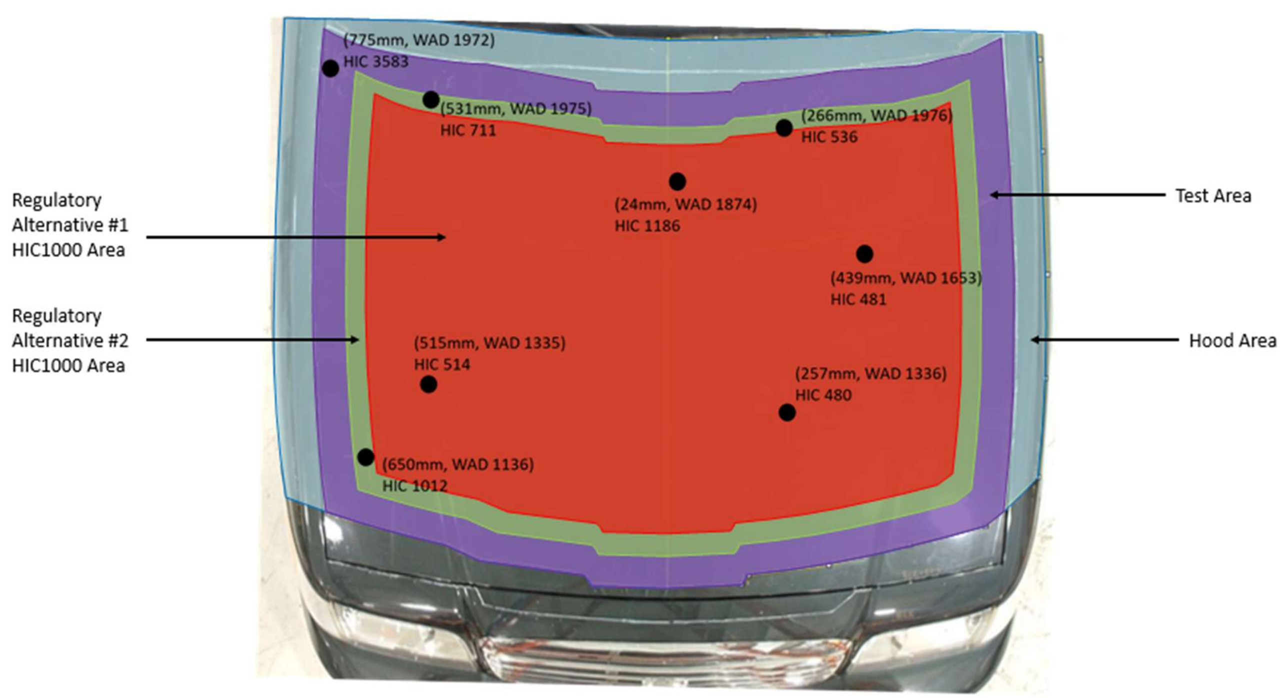


Figure 16: Hood Overlay for Regulatory Alternative

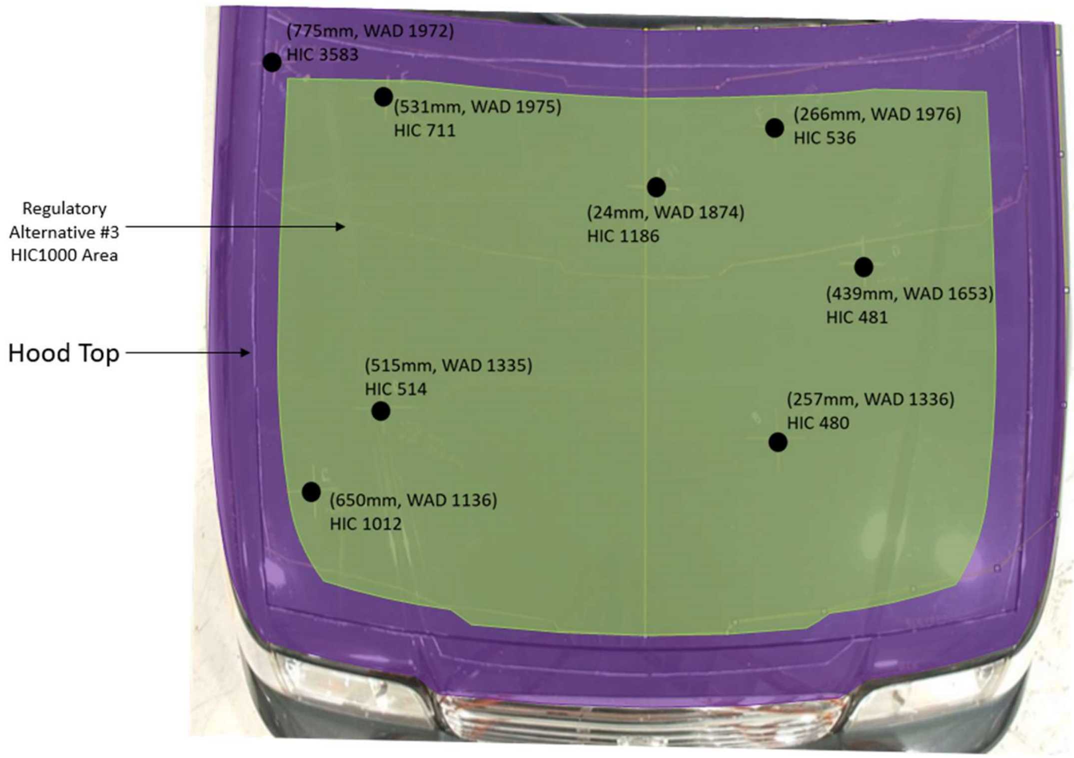


Table 140: Baseline Probability of Fatal and Non-Fatal Injuries for 2003 Ford Crown Victoria

Year	Vehicle	HIC	MAIS 1+F	MAIS 2+F	MAIS 3+F	MAIS 4+F	MAIS 5+F	Fatal
2003	Ford Crown Victoria	3583	0.997	0.925	0.839	0.808	0.797	0.792
2003	Ford Crown Victoria	1186	0.956	0.554	0.307	0.171	0.146	0.119
2003	Ford Crown Victoria	1012	0.939	0.479	0.236	0.112	0.093	0.071
2003	Ford Crown Victoria	711	0.885	0.320	0.116	0.036	0.027	0.018
2003	Ford Crown Victoria	536	0.821	0.211	0.057	0.012	0.008	0.004
2003	Ford Crown Victoria	514	0.810	0.197	0.051	0.010	0.007	0.004
2003	Ford Crown Victoria	481	0.791	0.176	0.042	0.007	0.005	0.002
2003	Ford Crown Victoria	480	0.791	0.176	0.042	0.007	0.005	0.002
Average			**0.874**	**0.380**	**0.211**	**0.145**	**0.136**	**0.127**

Under the proposed regulation, HIC values of 1012 and 1186 have impact locations within the HIC1000 area. To calculate rule effectiveness, these values are reduced to HIC=1000. Further, the test point with impact location in the top left corner is be reduced from HIC=3583 to

HIC=1700. After this treatment, average probabilities of MAIS 1-5 plus fatal were calculated. Table 141 shows this calculation.

Table 141: FMVSS No. 228 Probability of Fatal and Non-Fatal Injuries for 2003 Ford Crown Victoria

Within HIC1000	HIC	MAIS 1+F	MAIS 2+F	MAIS 3+F	MAIS 4+F	MAIS 5+F	Fatal
No	1700	0.980	0.712	0.492	0.360	0.330	0.298
Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
Yes	711	0.885	0.320	0.116	0.036	0.027	0.018
Yes	536	0.821	0.211	0.057	0.012	0.008	0.004
Yes	514	0.810	0.197	0.051	0.010	0.007	0.004
Yes	481	0.791	0.176	0.042	0.007	0.005	0.002
Yes	480	0.791	0.176	0.042	0.007	0.005	0.002
Average		**0.869**	**0.342**	**0.158**	**0.081**	**0.070**	**0.058**

Table 142 shows the percentage change in the probability of non-fatal and fatal injuries under the proposed rule for the 2003 Ford Crown Victoria. This example if for illustrative purposes. Baseline and improved average probabilities were calculated for all passenger cars, and separately for all LTV. These results are shown in Table 145 to Table 147 and Table 148 to Table 150, respectively.

Table 142: Percentage Change in Probability of Fatal and Non-Fatal Injury for 2003 Ford Crown Victoria

Injury Severity	Baseline	Proposed Rule	Percentage Change
MAIS 1+F	0.874	0.869	0.0%
MAIS 2+F	0.380	0.342	9.8%
MAIS 3+F	0.211	0.158	25.3%
MAIS 4+F	0.145	0.081	44.1%
MAIS 5+F	0.136	0.070	48.4%
Fatalities	0.127	0.058	54.1%

Using this example, regulatory alternative #1 differs in that the HIC=1012 value would not be reduced to HIC=1000 since it falls outside of the HIC1000 area (outside of the red area in Figure 15) that is two-thirds of the Test Area. Furthermore, under regulatory alternative #3, there is no HIC unlimited area and the remaining one-third of the Hood Top must meet the HIC 1700 requirement. Table 143 shows impact locations and HIC values that were reduced for all three regulatory alternatives. Calculations for regulatory alternatives #1 and #3 are shown in Table 151 to Table 154 and Table 155 to Table 158, respectively.

Table 143: Test Data Head Impact Criterion and Location for Passenger Cars

Vehicle	HIC	Regulatory Option: Within HIC1000 Area			Test Impact Speed (km/h)	Distance from Centerline (mm)	Wrap around Distance (mm)
		#1: EU Interpretation of GTR 9	#2: FMVSS 228	#3: Test Area = Hood Top			
Audi A4	1153	No	No	No	40	-700	1900
Audi A4	1085	No	No	No	40	-700	1300
Audi A4	1053	No	No	No	40	-700	1900
Audi A4	945	Yes	Yes	Yes	40	0	1100
Audi A4	875	No	No	No	40	0	1800
Audi A4	795	Yes	Yes	Yes	40	0	1100
Audi A4	766	No	No	No	40	-700	1300
Audi A4	703	Yes	Yes	Yes	40	500	1700
Audi A4	698	Yes	Yes	Yes	40	0	1700
Audi A4	621	Yes	Yes	Yes	40	0	1700
Audi A4	556	Yes	Yes	Yes	40	500	1700
Audi A4	450	No	No	No	40	0	1800
Buick Lacrosse	1602	No	No	No	35	769	1289
Buick Lacrosse	1026	No	No	No	35	220	1000
Buick Lacrosse	686	No	No	No	35	-369	1690
Buick Regal	1204	No	No	No	40.00	400	1800
Buick Regal	905	Yes	Yes	Yes	40.00	-400	1500
Buick Regal	834	No	No	Yes	40.00	400	1100
Buick Regal	817	No	No	No	40.00	0	1800
Buick Regal	673	No	No	No	35.00	400	1800
Buick Regal	641	No	No	Yes	40.00	0	1000
Buick Regal	574	No	No	Yes	35.00	400	1100
Buick Regal	452	No	No	Yes	35.00	0	1000

Buick Regal	396	Yes	Yes	Yes	40.00	0	1400
Cadillac ATS	2753	Yes	Yes	Yes	40.00	0	1500
Cadillac ATS	1923	No	Yes	Yes	40.00	600	1600
Cadillac ATS	1793	No	No	No	40.00	0	1800
Cadillac ATS	400	No	Yes	Yes	40.00	600	1600
Cadillac ATS	299	Yes	Yes	Yes	40.00	0	1500
Cadillac ATS	232	No	No	No	40.00	0	1800
Chevrolet Malibu	1470	No	No	No	40.00	-700	1900
Chevrolet Malibu	1203	No	No	Yes	40.00	0	1000
Chevrolet Malibu	1107	No	No	No	40.00	600	1300
Chevrolet Malibu	1096	No	No	Yes	40.00	-450	1100
Chevrolet Malibu	1013	No	No	Yes	40.00	0	1000
Chevrolet Malibu	864	Yes	Yes	Yes	40.00	-600	1700
Chevrolet Malibu	768	No	Yes	Yes	40.00	-500	1200
Chevrolet Malibu	762	Yes	Yes	Yes	40.00	-450	1350
Chevrolet Malibu	761	No	Yes	Yes	40.00	500	1800
Chevrolet Malibu	703	Yes	Yes	Yes	40.00	500	1500
Chevrolet Malibu	589	Yes	Yes	Yes	40.00	0	1700
Chevrolet Malibu	514	Yes	Yes	Yes	40.00	-450	1700
Chevrolet Malibu	397	Yes	Yes	Yes	40.00	200	1400
Chevrolet Malibu	376	Yes	Yes	Yes	40.00	0	1300
Chevrolet Malibu	374	Yes	Yes	Yes	40.00	0	1350
Ford Crown Victoria	3583	No	No	No	35	-775	1972
Ford Crown Victoria	1186	Yes	Yes	Yes	35	24	1874
Ford Crown Victoria	1012	No	Yes	Yes	35	-650	1136
Ford Crown Victoria	711	No	Yes	Yes	35	-531	1975
Ford Crown Victoria	536	No	Yes	Yes	35	266	1976
Ford Crown Victoria	514	Yes	Yes	Yes	35	-515	1335
Ford Crown Victoria	481	Yes	Yes	Yes	35	439	1653
Ford Crown Victoria	480	Yes	Yes	Yes	35	257	1336
Ford Focus	2199	No	No	No	40	-700	1700
Ford Focus	1400	Yes	Yes	Yes	40	-600	1600
Ford Focus	1250	Yes	Yes	Yes	40	600	1200
Ford Focus	1216	Yes	Yes	Yes	40	500	1300

Ford Focus	684	No	No	Yes	40	0	1000
Ford Focus	588	Yes	Yes	Yes	40	0	1500
Honda Civic	3215	No	No	No	32	675	1563
Honda Civic	2527	No	No	No	32	-655	1020
Honda Civic	2332	Yes	Yes	Yes	32	-570	1300
Honda Civic	1005	No	No	No	32	680	1460
Honda Civic	965	No	No	No	32	-680	1020
Honda Civic	722	Yes	Yes	Yes	32	-460	1345
Honda Civic	683	Yes	Yes	Yes	32	230	1345
Honda Civic	616	No	No	Yes	32	103	1010
Honda Civic	510	No	No	Yes	32	0	1010
Honda Civic	468	Yes	Yes	Yes	32	283	1363
Honda Fit	1223	No	Yes	Yes	40	-600	1400
Honda Fit	1053	Yes	Yes	Yes	40	-600	1100
Honda Fit	724	Yes	Yes	Yes	40	600	1300
Honda Fit*	658	No	No	No	40	0	1400
Honda Fit	624	No	No	Yes	40	0	1000
Honda Fit	431	No	Yes	Yes	40	300	1300
Honda Fit	380	Yes	Yes	Yes	40	-200	1200
Kia Forte	1587	No	No	No	35	-740	1130
Kia Forte	626	No	No	Yes	35	220	1000
Kia Forte	597	No	No	No	35	-370	1586
Toyota Camry	1759	No	No	No	32	-712	1715
Toyota Camry	1701	No	Yes	Yes	32	640	1476
Toyota Camry	733	No	Yes	Yes	32	0	1720
Toyota Camry	502	Yes	Yes	Yes	32	230	1350
Toyota Camry	454	Yes	Yes	Yes	32	-74	1164
Toyota Prius	1121	No	Yes	Yes	40	-600	1500
Toyota Prius	1021	No	No	Yes	40	-500	1100
Toyota Prius	999	No	No	Yes	40	-500	1100
Toyota Prius	793	No	Yes	Yes	40	-600	1200
Toyota Prius	740	Yes	Yes	Yes	40	-200	1100
Toyota Prius	659	Yes	Yes	Yes	40	500	1400
Toyota Prius	495	Yes	Yes	Yes	40	-200	1100
Toyota Prius	449	No	No	No	40	-100	1500
Toyota Prius	366	No	Yes	No	40	400	1500
Toyota Prius	350	Yes	Yes	Yes	40	0	1200
Toyota Prius	335	No	No	No	40	100	1500
Toyota Prius	313	No	Yes	No	40	400	1500

VW Arteon	1088	No	No	Yes	40	0	1000
VW Arteon	1050	No	No	Yes	40	0	1000
VW Arteon	913	No	Yes	Yes	40	400	1100
VW Arteon	835	No	No	Yes	40	400	1700
VW Arteon	833	No	No	No	40	0	1700
VW Arteon	775	No	Yes	Yes	40	400	1100
VW Arteon	708	No	No	Yes	35.00	0	1000
VW Arteon	526	No	No	No	35.00	0	1700
VW Arteon	505	Yes	Yes	Yes	40.00	400	1400
VW Arteon	484	No	No	No	40.00	0	1700
VW Arteon	467	Yes	Yes	Yes	40.00	0	1400
VW Arteon	414	Yes	Yes	Yes	40.00	400	1400
VW Arteon	411	No	No	Yes	40.00	400	1700
VW Arteon	394	Yes	Yes	Yes	40.00	0	1400
VW Arteon	338	Yes	Yes	Yes	35.00	400	1400
VW Passat	1302	No	No	No	35	-683	1501
VW Passat	836	No	No	No	35	0	1698
VW Passat	734	Yes	Yes	Yes	35	-480	1346
VW Passat	565	Yes	Yes	Yes	35	435	1174
VW Passat	378	Yes	Yes	Yes	35	240	1346

*Outside of Test Area for Regulatory Options #1 and #2 but in Test Area for #3 . Excluded from Analysis.

Table 144: Test Data Head Impact Criterion and Location for LTV

Vehicle	HIC	Regulatory Option: Within HIC1000 Area			Test Impact Speed (m/s)	Distance from Centerline (mm)	Wrap around Distance (mm)
		#1: EU Interpretation of GTR 9	#2: FMVSS 228	#3: Test Area = Hood Top			
Acura MDX	1696	No	No	No	35	-740	1755
Acura MDX	1283	No	No	No	35	183	1120
Acura MDX	1100	No	No	No	35	607	1700
Acura MDX	785	No	No	No	35	-670	1151
Acura MDX	550	Yes	Yes	Yes	35	174	1700
Chevrolet Silverado	1274	No	No	No	35	291	1342
Chevrolet Silverado	1133	No	No	No	35	779	2095
Chevrolet Silverado	1048	No	No	No	35	750	1337
Chevrolet Silverado	929	No	No	Yes	35	0	1340
Chevrolet Silverado	889	No	No	Yes	35	-580	1335

Chevrolet Silverado	864	No	Yes	Yes	35	-310	2030
Chevrolet Silverado	833	Yes	Yes	Yes	35	-632	1705
Chevrolet Silverado	740	Yes	Yes	Yes	35	320	1705
Chevrolet Tahoe	2320	No	No	No	40	0	1200
Chevrolet Tahoe	2122	No	No	No	40	800	1500
Chevrolet Tahoe	1622	No	Yes	Yes	40	300	1300
Chevrolet Tahoe	1502	No	No	No	40	-700	2200
Chevrolet Tahoe	1050	No	Yes	Yes	40	-700	1900
Chevrolet Tahoe	979	Yes	Yes	Yes	40	500	2000
Chevrolet Tahoe	764	No	Yes	Yes	40	-700	1700
Chevrolet Tahoe	615	No	No	No	40	0	2100
Chevrolet Tahoe	611	Yes	Yes	Yes	40	-300	1600
Chevrolet Tahoe	506	Yes	Yes	Yes	40	0	1700
Chevrolet Tahoe	398	Yes	Yes	Yes	40	200	1900
Dodge Dakota	2276	No	No	No	35	-707	1960
Dodge Dakota	1737	No	No	Yes	35	622	1986
Dodge Dakota	1658	No	No	No	35	0	1056
Dodge Dakota	1483	Yes	Yes	Yes	35	-519	1104
Dodge Dakota	1203	Yes	Yes	Yes	35	260	1104
Dodge Dakota	859	Yes	Yes	Yes	35	-514	1705
Dodge Dakota	763	Yes	Yes	Yes	35	257	1706
Dodge Dakota	448	Yes	Yes	Yes	35	-284	1308
Dodge Durango	1766	No	Yes	Yes	35	699	1858
Dodge Durango	1685	No	No	No	35	186	1197
Dodge Durango	1032	No	No	No	35	-372	1194
Dodge Durango	981	Yes	Yes	Yes	35	-120	1900
Dodge Durango	769	Yes	Yes	Yes	35	-590	1493
Dodge Durango	729	Yes	Yes	Yes	35	-481	1704
Dodge Durango	476	Yes	Yes	Yes	35	230	1707
Dodge Durango	343	Yes	Yes	Yes	35	233	1508
Dodge Ram	1321	No	No	No	32	310	1430
Dodge Ram	1193	No	No	No	32	-620	1410
Dodge Ram	626	Yes	Yes	Yes	32	603	1700
Dodge Ram	614	Yes	Yes	Yes	32	0	1710
Dodge Ram	555	Yes	Yes	Yes	32	-620	1745
Ford E350	3993	No	Yes	Yes	35	856	1792
Ford E350	2448	No	No	Yes	35	609	1808

Ford E350	1433	No	Yes	Yes	35	276	1274
Ford E350	1422	No	Yes	Yes	35	0	1278
Ford E350	1394	No	Yes	Yes	35	-547	1264
Ford E350	1321	Yes	Yes	Yes	35	282	1706
Ford E350	1297	Yes	Yes	Yes	35	-568	1704
Ford E350	868	Yes	Yes	Yes	35	561	1480
Ford Edge*	1452	No	No	No	40	-400	1100
Ford Edge	1297	No	No	No	40	-700	1900
Ford Edge	1079	No	Yes	Yes	40	600	1300
Ford Edge	822	No	No	Yes	40	0	1100
Ford Edge	805	No	No	No	40	500	1800
Ford Edge	792	No	No	No	40	0	1800
Ford Edge	740	Yes	Yes	Yes	40	-600	1600
Ford Edge	543	Yes	Yes	Yes	40	-500	1500
Ford Edge	524	Yes	Yes	Yes	40	300	1600
Ford Edge	467	Yes	Yes	Yes	40	0	1400
Ford Escape	2292	No	No	No	32	685	1825
Ford Escape	1230	Yes	Yes	Yes	32	-465	1700
Ford Escape	1131	No	No	No	32	670	1140
Ford Escape	948	No	No	Yes	32	-450	1070
Ford Escape	839	Yes	Yes	Yes	32	230	1715
Ford Escape	708	No	Yes	Yes	32	225	1090
Ford Escape	406	Yes	Yes	Yes	32	115	1360
Ford F-150	3163	No	No	No	40	-800	1600
Ford F-150	2576	No	No	No	40	-800	2300
Ford F-150	1862	No	No	No	40	0	1200
Ford F-150*	1466	No	No	No	40	700	1400
Ford F-150*	1244	No	No	No	40	-500	1300
Ford F-150	1121	No	Yes	Yes	40	-300	1300
Ford F-150	1070	Yes	Yes	Yes	40	0	1500
Ford F-150	1043	Yes	Yes	Yes	40	-500	1800
Ford F-150	999	No	No	No	40	0	2100
Ford F-150	575	Yes	Yes	Yes	40	400	2000
Ford Ranger (Al)	1541	Yes	Yes	Yes	40	0	1200
Ford Ranger (Al)	1117	No	Yes	Yes	40	400	1900
Ford Ranger (Al)	351	Yes	Yes	Yes	40	-300	1600
Ford Ranger (Steel)	1602	Yes	Yes	Yes	40	0	1200
Ford Ranger (Steel)	1033	No	Yes	Yes	40	400	1900

Ford Ranger (Steel)	751	Yes	Yes	Yes	40	-300	1600
GMC Savana	984	Yes	Yes	Yes	32	760	1590
GMC Savana	585	No	Yes	Yes	32	270	1380
GMC Savana	582	No	Yes	Yes	32	-560	1380
GMC Savana	524	Yes	Yes	Yes	32	0	1515
Honda CRV	1660	No	No	Yes	35	-701	1704
Honda CRV	1224	No	Yes	Yes	35	652	1706
Honda CRV	1197	No	No	No	35	-634	1050
Honda CRV	1054	No	No	Yes	35	692	1399
Honda CRV	1013	No	Yes	Yes	35	237	1705
Honda CRV	938	No	Yes	Yes	35	-470	1705
Honda CRV*	926	No	No	No	35	76	1822
Honda CRV	749	No	No	Yes	35	-456	1081
Honda CRV	671	No	No	Yes	35	228	1087
Honda CRV*	626	No	No	No	35	3	1072
Honda CRV*	508	No	No	No	35	-292	1810
Honda Odyssey	1358	No	No	No	35	413	1555
Honda Odyssey	1302	No	No	No	35	709	1000
Honda Odyssey	1129	No	No	Yes	35	-186	1000
Honda Odyssey	731	Yes	Yes	Yes	35	-675	1276
Hummer H2	6773	No	Yes	Yes	35	382	1328
Hummer H2	4594	No	No	No	35	289	1275
Hummer H2	4252	No	Yes	Yes	35	-578	1270
Hummer H2	2307	Yes	Yes	Yes	35	765	1445
Hummer H2	1493	No	No	Yes	35	126	2053
Hummer H2	1220	Yes	Yes	Yes	35	-534	1705
Hummer H2	1220	Yes	Yes	Yes	35	487	1856
Hummer H2	909	Yes	Yes	Yes	35	267	1727
Hyundai Tucson	1484	No	No	No	35	783	1482
Hyundai Tucson	1036	No	No	No	35	-660	1704
Hyundai Tucson	638	No	No	No	35	120	1000
Hyundai Tucson	461	No	No	No	35	126	1700
Jeep Grand Cherokee	979	No	No	No	35	795	1655
Jeep Grand Cherokee	877	No	No	No	35	-500	2000
Jeep Grand Cherokee	651	No	No	No	35	50	1190
Jeep Grand Cherokee	491	Yes	Yes	Yes	35	400	1700

Jeep Wrangler	4302	No	Yes	Yes	35	350	2071
Jeep Wrangler	3574	No	Yes	Yes	35	603	1072
Jeep Wrangler	2902	No	Yes	Yes	35	534	2014
Jeep Wrangler	1699	Yes	Yes	Yes	35	-501	1153
Jeep Wrangler	1697	No	No	Yes	35	250	1168
Jeep Wrangler	553	Yes	Yes	Yes	35	-389	1705
Jeep Wrangler	456	Yes	Yes	Yes	35	195	1705
Jeep Wrangler	379	Yes	Yes	Yes	35	-246	1599
Nissan Rogue	1096	No	No	No	40	700	1900
Nissan Rogue	1074	No	No	No	40	-700	1300
Nissan Rogue	715	No	No	No	40	-500	1800
Nissan Rogue	690	Yes	Yes	Yes	40	500	1400
Nissan Rogue	566	Yes	Yes	Yes	40	0	1400
Nissan Rogue	563	No	No	No	40	0	1800
Nissan Rogue	532	No	Yes	Yes	40	700	1600
Nissan Rogue	423	Yes	Yes	Yes	40	-200	1600
Subaru Outback	1077	No	No	No	40	-700	1900
Subaru Outback	1055	No	No	No	40	-700	1900
Subaru Outback	1023	No	No	Yes	40	400	1100
Subaru Outback	992	No	No	No	40	-700	1300
Subaru Outback	758	No	No	No	40	-700	1500
Subaru Outback	741	No	Yes	Yes	40	0	1100
Subaru Outback	719	No	No	Yes	35.00	400	1100
Subaru Outback	612	No	Yes	Yes	35.00	0	1100
Subaru Outback	545	Yes	Yes	Yes	40.00	400	1500
Subaru Outback	441	Yes	Yes	Yes	11.09	0	1500
Subaru Outback	418	No	Yes	Yes	11.09	400	1800
Subaru Outback	329	No	Yes	Yes	11.09	0	1800
Subaru Outback	305	Yes	Yes	Yes	35.00	0	1500
Toyota 4-Runner	2288	No	No	No	35.00	-729	1908
Toyota 4-Runner	1774	No	No	Yes	35.00	739	1705
Toyota 4-Runner	1756	No	No	No	35.00	-471	1114
Toyota 4-Runner	1344	No	No	No	35.00	236	1171
Toyota 4-Runner	838	Yes	Yes	Yes	35.00	-377	1280
Toyota 4-Runner	732	Yes	Yes	Yes	35.00	280	1706
Toyota 4-Runner	580	Yes	Yes	Yes	35.00	-497	1710
Toyota 4-Runner	356	Yes	Yes	Yes	35.00	-385	1472
Toyota Sienna	1363	No	No	Yes	32	-755	1535
Toyota Sienna	1319	Yes	Yes	Yes	40	700	1300

Toyota Sienna	1250	Yes	Yes	Yes	40		1300
Toyota Sienna	1209	No	Yes	Yes	40	-700	1600
Toyota Sienna	909	No	No	Yes	40	0	1000
Toyota Sienna	839	No	Yes	Yes	40	300	1100
Toyota Sienna	705	Yes	Yes	Yes	40		1200
Toyota Sienna	655	No	No	Yes	40	0	1500
Toyota Sienna	598	Yes	Yes	Yes	32	-550	1215
Toyota Sienna	596	Yes	Yes	Yes	40	-400	1400
Toyota Sienna	518	No	No	Yes	32	250	1535
Toyota Sienna	403	Yes	Yes	Yes	32	255	1208
Toyota Sienna	353	Yes	Yes	Yes	32	0	1380
Toyota Tacoma	1814	No	No	No	35	716	1942
Toyota Tacoma	1443	No	No	No	35	-726	1706
Toyota Tacoma	1385	No	No	No	35	693	1103
Toyota Tacoma	947	No	No	No	35	243	1100
Toyota Tacoma	889	No	No	No	35	-487	1110
Toyota Tacoma	513	Yes	Yes	Yes	35	-487	1710
Toyota Tacoma	415	Yes	Yes	Yes	35	243	1710
Toyota Tacoma	309	Yes	Yes	Yes	35	275	1462

* Outside of Test Area for Regulatory Options #1 and #2 but in Test Area for #3. Excluded from Analysis.

Table 145: Baseline Probability of Fatal and Non-Fatal Injuries for Passenger Cars

Year	Vehicle	HIC	MAIS 1+F	MAIS 2+F	MAIS 3+F	MAIS 4+F	MAIS 5+F	Fatal
2017	Audi A4	1153	0.953	0.541	0.293	0.159	0.136	0.109
2017	Audi A4	1085	0.947	0.512	0.266	0.136	0.114	0.090
2017	Audi A4	1053	0.944	0.498	0.253	0.125	0.105	0.082
2017	Audi A4	945	0.931	0.447	0.208	0.092	0.075	0.056
2017	Audi A4	875	0.920	0.412	0.180	0.073	0.058	0.042
2017	Audi A4	795	0.905	0.368	0.148	0.054	0.042	0.029
2017	Audi A4	766	0.898	0.352	0.137	0.047	0.036	0.024
2017	Audi A4	703	0.882	0.315	0.113	0.035	0.026	0.017
2017	Audi A4	698	0.881	0.312	0.111	0.034	0.025	0.016
2017	Audi A4	621	0.856	0.265	0.084	0.022	0.016	0.009
2017	Audi A4	556	0.830	0.224	0.063	0.014	0.010	0.005
2017	Audi A4	450	0.772	0.157	0.035	0.005	0.003	0.002
2010	Buick Lacrosse	1602	0.977	0.688	0.461	0.324	0.295	0.262
2010	Buick Lacrosse	1026	0.941	0.486	0.242	0.117	0.097	0.075
2010	Buick Lacrosse	686	0.878	0.305	0.107	0.032	0.024	0.015
2018	Buick Regal	1204	0.957	0.561	0.314	0.177	0.152	0.124
2018	Buick Regal	905	0.925	0.427	0.192	0.081	0.065	0.048

2018	Buick Regal	834	0.913	0.390	0.163	0.063	0.049	0.035
2018	Buick Regal	817	0.909	0.380	0.157	0.059	0.046	0.032
2018	Buick Regal	673	0.874	0.297	0.102	0.030	0.022	0.014
2018	Buick Regal	641	0.863	0.277	0.091	0.025	0.018	0.011
2018	Buick Regal	574	0.838	0.235	0.069	0.016	0.011	0.006
2018	Buick Regal	452	0.773	0.158	0.035	0.006	0.004	0.002
2018	Buick Regal	396	0.732	0.123	0.023	0.003	0.002	0.001
2017	Cadillac ATS	2753	0.994	0.871	0.737	0.668	0.649	0.633
2017	Cadillac ATS	1923	0.986	0.760	0.559	0.438	0.409	0.379
2017	Cadillac ATS	1793	0.983	0.734	0.521	0.393	0.364	0.332
2017	Cadillac ATS	400	0.735	0.125	0.024	0.003	0.002	0.001
2017	Cadillac ATS	299	0.633	0.068	0.009	0.001	0.000	0.000
2017	Cadillac ATS	232	0.536	0.037	0.003	0.000	0.000	0.000
2016	Chevrolet Malibu	1470	0.972	0.651	0.415	0.275	0.246	0.214
2016	Chevrolet Malibu	1203	0.957	0.561	0.313	0.177	0.152	0.124
2016	Chevrolet Malibu	1107	0.949	0.522	0.275	0.143	0.121	0.096
2016	Chevrolet Malibu	1096	0.948	0.517	0.270	0.140	0.118	0.093
2016	Chevrolet Malibu	1013	0.939	0.480	0.236	0.113	0.093	0.071
2016	Chevrolet Malibu	864	0.918	0.406	0.175	0.070	0.056	0.040
2016	Chevrolet Malibu	768	0.899	0.353	0.137	0.048	0.037	0.025
2016	Chevrolet Malibu	762	0.897	0.349	0.135	0.046	0.036	0.024
2016	Chevrolet Malibu	761	0.897	0.349	0.135	0.046	0.035	0.024
2016	Chevrolet Malibu	703	0.882	0.315	0.113	0.035	0.026	0.017
2016	Chevrolet Malibu	589	0.844	0.245	0.073	0.018	0.012	0.007
2016	Chevrolet Malibu	514	0.810	0.197	0.051	0.010	0.007	0.004
2016	Chevrolet Malibu	397	0.733	0.124	0.024	0.003	0.002	0.001
2016	Chevrolet Malibu	376	0.715	0.111	0.020	0.002	0.001	0.001
2016	Chevrolet Malibu	374	0.713	0.110	0.019	0.002	0.001	0.001
2003	Ford Crown	3583	0.997	0.925	0.839	0.808	0.797	0.792

	Victoria							
2003	Ford Crown Victoria	1186	0.956	0.554	0.307	0.171	0.146	0.119
2003	Ford Crown Victoria	1012	0.939	0.479	0.236	0.112	0.093	0.071
2003	Ford Crown Victoria	711	0.885	0.320	0.116	0.036	0.027	0.018
2003	Ford Crown Victoria	536	0.821	0.211	0.057	0.012	0.008	0.004
2003	Ford Crown Victoria	514	0.810	0.197	0.051	0.010	0.007	0.004
2003	Ford Crown Victoria	481	0.791	0.176	0.042	0.007	0.005	0.002
2003	Ford Crown Victoria	480	0.791	0.176	0.042	0.007	0.005	0.002
2011	Ford Focus	2199	0.990	0.806	0.629	0.526	0.500	0.474
2011	Ford Focus	1400	0.969	0.630	0.389	0.249	0.221	0.189
2011	Ford Focus	1250	0.961	0.578	0.332	0.193	0.168	0.139
2011	Ford Focus	1216	0.958	0.566	0.319	0.181	0.156	0.128
2011	Ford Focus	684	0.877	0.303	0.106	0.032	0.023	0.015
2011	Ford Focus	588	0.844	0.244	0.073	0.018	0.012	0.007
2001	Honda Civic	1005	0.938	0.476	0.233	0.110	0.091	0.070
2001	Honda Civic	965	0.933	0.457	0.217	0.098	0.080	0.060
2001	Honda Civic	722	0.888	0.326	0.120	0.038	0.029	0.019
2001	Honda Civic	683	0.877	0.303	0.105	0.031	0.023	0.015
2001	Honda Civic	510	0.808	0.195	0.050	0.010	0.006	0.003
1994	Honda Civic	3215	0.996	0.905	0.800	0.755	0.741	0.732
1994	Honda Civic	2527	0.993	0.848	0.697	0.616	0.593	0.573
1994	Honda Civic	2332	0.991	0.825	0.658	0.564	0.539	0.516
1994	Honda Civic	616	0.855	0.262	0.082	0.021	0.015	0.009
1994	Honda Civic	468	0.784	0.168	0.039	0.006	0.004	0.002
2016	Honda Fit	1223	0.959	0.568	0.321	0.184	0.159	0.130
2016	Honda Fit	1053	0.944	0.498	0.253	0.125	0.105	0.082
2016	Honda Fit	724	0.888	0.327	0.121	0.039	0.029	0.019
2016	Honda Fit	624	0.858	0.267	0.085	0.022	0.016	0.010
2016	Honda Fit	431	0.759	0.145	0.031	0.004	0.003	0.001
2016	Honda Fit	380	0.718	0.113	0.021	0.002	0.001	0.001
2010	Kia Forte	1587	0.977	0.684	0.456	0.318	0.289	0.256
2010	Kia Forte	626	0.858	0.268	0.086	0.022	0.016	0.010
2010	Kia Forte	597	0.847	0.250	0.076	0.019	0.013	0.008
2004	Toyota Camry	1759	0.982	0.726	0.511	0.381	0.352	0.320
2004	Toyota Camry	1701	0.980	0.713	0.493	0.360	0.331	0.298
2004	Toyota Camry	733	0.890	0.333	0.124	0.040	0.031	0.020

2004	Toyota Camry	502	0.803	0.190	0.048	0.009	0.006	0.003
2004	Toyota Camry	454	0.775	0.159	0.036	0.006	0.004	0.002
2016	Toyota Prius	1121	0.950	0.527	0.280	0.148	0.126	0.100
2016	Toyota Prius	1021	0.940	0.483	0.240	0.115	0.096	0.073
2016	Toyota Prius	999	0.938	0.473	0.230	0.108	0.089	0.068
2016	Toyota Prius	793	0.904	0.367	0.147	0.053	0.041	0.028
2016	Toyota Prius	740	0.892	0.337	0.127	0.042	0.032	0.021
2016	Toyota Prius	659	0.869	0.288	0.097	0.027	0.020	0.013
2016	Toyota Prius	495	0.800	0.185	0.046	0.008	0.006	0.003
2016	Toyota Prius	449	0.771	0.156	0.035	0.005	0.003	0.002
2016	Toyota Prius	366	0.706	0.105	0.018	0.002	0.001	0.000
2016	Toyota Prius	350	0.690	0.096	0.016	0.002	0.001	0.000
2016	Toyota Prius	335	0.675	0.087	0.013	0.001	0.001	0.000
2016	Toyota Prius	313	0.650	0.075	0.011	0.001	0.000	0.000
2021	VW Arteon	1088	0.947	0.513	0.267	0.137	0.115	0.091
2021	VW Arteon	1050	0.944	0.497	0.252	0.125	0.104	0.081
2021	VW Arteon	913	0.926	0.431	0.195	0.083	0.067	0.049
2021	VW Arteon	835	0.913	0.390	0.164	0.063	0.050	0.035
2021	VW Arteon	833	0.912	0.389	0.163	0.062	0.049	0.035
2021	VW Arteon	775	0.900	0.357	0.140	0.049	0.038	0.026
2021	VW Arteon	708	0.884	0.318	0.115	0.036	0.027	0.017
2021	VW Arteon	526	0.816	0.205	0.054	0.011	0.007	0.004
2021	VW Arteon	505	0.805	0.191	0.048	0.009	0.006	0.003
2021	VW Arteon	484	0.793	0.178	0.043	0.008	0.005	0.003
2021	VW Arteon	467	0.783	0.167	0.039	0.006	0.004	0.002
2021	VW Arteon	414	0.746	0.134	0.027	0.004	0.002	0.001
2021	VW Arteon	411	0.744	0.132	0.026	0.003	0.002	0.001
2021	VW Arteon	394	0.730	0.122	0.023	0.003	0.002	0.001
2021	VW Arteon	338	0.678	0.089	0.014	0.001	0.001	0.000
2006	VW Passat	1302	0.964	0.597	0.352	0.212	0.186	0.156
2006	VW Passat	836	0.913	0.391	0.164	0.063	0.050	0.035
2006	VW Passat	734	0.891	0.333	0.124	0.041	0.031	0.020
2006	VW Passat	565	0.834	0.230	0.066	0.015	0.010	0.006
2006	VW Passat	378	0.717	0.112	0.020	0.002	0.001	0.001
Average		**881.56**	**0.867**	**0.363**	**0.181**	**0.104**	**0.092**	**0.080**

Table 146: FMVSS No. 228 Probability of Fatal and Non-Fatal Injuries for Passenger Cars

Year	Vehicle	Within HIC1000	Treated HIC	MAIS 1+F	MAIS 2+F	MAIS 3+F	MAIS 4+F	MAIS 5+F	Fatal
2017	Audi A4	No	1153	0.953	0.541	0.293	0.159	0.136	0.109
2017	Audi A4	No	1085	0.947	0.512	0.266	0.136	0.114	0.090

2017	Audi A4	No	1053	0.944	0.498	0.253	0.125	0.105	0.082
2017	Audi A4	Yes	945	0.931	0.447	0.208	0.092	0.075	0.056
2017	Audi A4	No	875	0.920	0.412	0.180	0.073	0.058	0.042
2017	Audi A4	Yes	795	0.905	0.368	0.148	0.054	0.042	0.029
2017	Audi A4	No	766	0.898	0.352	0.137	0.047	0.036	0.024
2017	Audi A4	Yes	703	0.882	0.315	0.113	0.035	0.026	0.017
2017	Audi A4	Yes	698	0.881	0.312	0.111	0.034	0.025	0.016
2017	Audi A4	Yes	621	0.856	0.265	0.084	0.022	0.016	0.009
2017	Audi A4	Yes	556	0.830	0.224	0.063	0.014	0.010	0.005
2017	Audi A4	No	450	0.772	0.157	0.035	0.005	0.003	0.002
2010	Buick Lacrosse	No	1602	0.977	0.688	0.461	0.324	0.295	0.262
2010	Buick Lacrosse	No	1026	0.941	0.486	0.242	0.117	0.097	0.075
2010	Buick Lacrosse	No	686	0.878	0.305	0.107	0.032	0.024	0.015
2018	Buick Regal	No	1204	0.957	0.561	0.314	0.177	0.152	0.124
2018	Buick Regal	Yes	905	0.925	0.427	0.192	0.081	0.065	0.048
2018	Buick Regal	No	834	0.913	0.390	0.163	0.063	0.049	0.035
2018	Buick Regal	No	817	0.909	0.380	0.157	0.059	0.046	0.032
2018	Buick Regal	No	673	0.874	0.297	0.102	0.030	0.022	0.014
2018	Buick Regal	No	641	0.863	0.277	0.091	0.025	0.018	0.011
2018	Buick Regal	No	574	0.838	0.235	0.069	0.016	0.011	0.006
2018	Buick Regal	No	452	0.773	0.158	0.035	0.006	0.004	0.002
2018	Buick Regal	Yes	396	0.732	0.123	0.023	0.003	0.002	0.001
2017	Cadillac ATS	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2017	Cadillac ATS	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2017	Cadillac ATS	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2017	Cadillac ATS	Yes	400	0.735	0.125	0.024	0.003	0.002	0.001
2017	Cadillac ATS	Yes	299	0.633	0.068	0.009	0.001	0.000	0.000

2017	Cadillac ATS	No	232	0.536	0.037	0.003	0.000	0.000	0.000
2016	Chevrolet Malibu	No	1470	0.972	0.651	0.415	0.275	0.246	0.214
2016	Chevrolet Malibu	No	1203	0.957	0.561	0.313	0.177	0.152	0.124
2016	Chevrolet Malibu	No	1107	0.949	0.522	0.275	0.143	0.121	0.096
2016	Chevrolet Malibu	No	1096	0.948	0.517	0.270	0.140	0.118	0.093
2016	Chevrolet Malibu	No	1013	0.939	0.480	0.236	0.113	0.093	0.071
2016	Chevrolet Malibu	Yes	864	0.918	0.406	0.175	0.070	0.056	0.040
2016	Chevrolet Malibu	Yes	768	0.899	0.353	0.137	0.048	0.037	0.025
2016	Chevrolet Malibu	Yes	762	0.897	0.349	0.135	0.046	0.036	0.024
2016	Chevrolet Malibu	Yes	761	0.897	0.349	0.135	0.046	0.035	0.024
2016	Chevrolet Malibu	Yes	703	0.882	0.315	0.113	0.035	0.026	0.017
2016	Chevrolet Malibu	Yes	589	0.844	0.245	0.073	0.018	0.012	0.007
2016	Chevrolet Malibu	Yes	514	0.810	0.197	0.051	0.010	0.007	0.004
2016	Chevrolet Malibu	Yes	397	0.733	0.124	0.024	0.003	0.002	0.001
2016	Chevrolet Malibu	Yes	376	0.715	0.111	0.020	0.002	0.001	0.001
2016	Chevrolet Malibu	Yes	374	0.713	0.110	0.019	0.002	0.001	0.001
2003	Ford Crown Victoria	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2003	Ford Crown Victoria	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Ford Crown Victoria	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Ford Crown Victoria	Yes	711	0.885	0.320	0.116	0.036	0.027	0.018
2003	Ford Crown	Yes	536	0.821	0.211	0.057	0.012	0.008	0.004

	Victoria									
2003	Ford Crown Victoria	Yes	514	0.810	0.197	0.051	0.010	0.007	0.004
2003	Ford Crown Victoria	Yes	481	0.791	0.176	0.042	0.007	0.005	0.002
2003	Ford Crown Victoria	Yes	480	0.791	0.176	0.042	0.007	0.005	0.002
2011	Ford Focus	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2011	Ford Focus	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2011	Ford Focus	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2011	Ford Focus	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2011	Ford Focus	No	684	0.877	0.303	0.106	0.032	0.023	0.015
2011	Ford Focus	Yes	588	0.844	0.244	0.073	0.018	0.012	0.007
2001	Honda Civic	No	1005	0.938	0.476	0.233	0.110	0.091	0.070
2001	Honda Civic	No	965	0.933	0.457	0.217	0.098	0.080	0.060
2001	Honda Civic	Yes	722	0.888	0.326	0.120	0.038	0.029	0.019
2001	Honda Civic	Yes	683	0.877	0.303	0.105	0.031	0.023	0.015
2001	Honda Civic	No	510	0.808	0.195	0.050	0.010	0.006	0.003
1994	Honda Civic	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
1994	Honda Civic	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
1994	Honda Civic	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
1994	Honda Civic	No	616	0.855	0.262	0.082	0.021	0.015	0.009
1994	Honda Civic	Yes	468	0.784	0.168	0.039	0.006	0.004	0.002
2016	Honda Fit	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2016	Honda Fit	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2016	Honda Fit	Yes	724	0.888	0.327	0.121	0.039	0.029	0.019
2016	Honda Fit	No	624	0.858	0.267	0.085	0.022	0.016	0.010
2016	Honda Fit	Yes	431	0.759	0.145	0.031	0.004	0.003	0.001
2016	Honda Fit	Yes	380	0.718	0.113	0.021	0.002	0.001	0.001
2010	Kia Forte	No	1587	0.977	0.684	0.456	0.318	0.289	0.256
2010	Kia Forte	No	626	0.858	0.268	0.086	0.022	0.016	0.010

2010	Kia Forte	No	597	0.847	0.250	0.076	0.019	0.013	0.008
2004	Toyota Camry	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2004	Toyota Camry	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2004	Toyota Camry	Yes	733	0.890	0.333	0.124	0.040	0.031	0.020
2004	Toyota Camry	Yes	502	0.803	0.190	0.048	0.009	0.006	0.003
2004	Toyota Camry	Yes	454	0.775	0.159	0.036	0.006	0.004	0.002
2016	Toyota Prius	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2016	Toyota Prius	No	1021	0.940	0.483	0.240	0.115	0.096	0.073
2016	Toyota Prius	No	999	0.938	0.473	0.230	0.108	0.089	0.068
2016	Toyota Prius	Yes	793	0.904	0.367	0.147	0.053	0.041	0.028
2016	Toyota Prius	Yes	740	0.892	0.337	0.127	0.042	0.032	0.021
2016	Toyota Prius	Yes	659	0.869	0.288	0.097	0.027	0.020	0.013
2016	Toyota Prius	Yes	495	0.800	0.185	0.046	0.008	0.006	0.003
2016	Toyota Prius	No	449	0.771	0.156	0.035	0.005	0.003	0.002
2016	Toyota Prius	Yes	366	0.706	0.105	0.018	0.002	0.001	0.000
2016	Toyota Prius	Yes	350	0.690	0.096	0.016	0.002	0.001	0.000
2016	Toyota Prius	No	335	0.675	0.087	0.013	0.001	0.001	0.000
2016	Toyota Prius	Yes	313	0.650	0.075	0.011	0.001	0.000	0.000
2021	VW Arteon	No	1088	0.947	0.513	0.267	0.137	0.115	0.091
2021	VW Arteon	No	1050	0.944	0.497	0.252	0.125	0.104	0.081
2021	VW Arteon	Yes	913	0.926	0.431	0.195	0.083	0.067	0.049
2021	VW Arteon	No	835	0.913	0.390	0.164	0.063	0.050	0.035
2021	VW Arteon	No	833	0.912	0.389	0.163	0.062	0.049	0.035

2021	VW Arteon	Yes	775	0.900	0.357	0.140	0.049	0.038	0.026
2021	VW Arteon	No	708	0.884	0.318	0.115	0.036	0.027	0.017
2021	VW Arteon	No	526	0.816	0.205	0.054	0.011	0.007	0.004
2021	VW Arteon	Yes	505	0.805	0.191	0.048	0.009	0.006	0.003
2021	VW Arteon	No	484	0.793	0.178	0.043	0.008	0.005	0.003
2021	VW Arteon	Yes	467	0.783	0.167	0.039	0.006	0.004	0.002
2021	VW Arteon	Yes	414	0.746	0.134	0.027	0.004	0.002	0.001
2021	VW Arteon	No	411	0.744	0.132	0.026	0.003	0.002	0.001
2021	VW Arteon	Yes	394	0.730	0.122	0.023	0.003	0.002	0.001
2021	VW Arteon	Yes	338	0.678	0.089	0.014	0.001	0.001	0.000
2006	VW Passat	No	1302	0.964	0.597	0.352	0.212	0.186	0.156
2006	VW Passat	No	836	0.913	0.391	0.164	0.063	0.050	0.035
2006	VW Passat	Yes	734	0.891	0.333	0.124	0.041	0.031	0.020
2006	VW Passat	Yes	565	0.834	0.230	0.066	0.015	0.010	0.006
2006	VW Passat	Yes	378	0.717	0.112	0.020	0.002	0.001	0.001
Average			**785.51**	**0.864**	**0.341**	**0.154**	**0.074**	**0.063**	**0.050**

Table 147 shows the percentage change in the probability of non-fatal and fatal injuries under the proposed rule for passenger cars.

Table 147: Percentage Change in Probability of Fatal and Non-Fatal Injury for Passenger Cars

Injury Severity	**Baseline**	**Proposed Rule**	**Percentage Change**
MAIS 1+F	0.867	0.864	0.4%
MAIS 2+F	0.363	0.341	6.1%
MAIS 3+F	0.181	0.154	15.1%
MAIS 4+F	0.104	0.074	28.5%
MAIS 5+F	0.092	0.063	31.9%
Fatalities	0.080	0.050	37.0%

Analogous calculations were made for LTV. These calculations are shown in Table 148, Table 149, and Table 150.

Table 148: Baseline Probability of Fatal and Non-Fatal Injuries for LTV

Year	Vehicle	HIC	MAIS 1+F	MAIS 2+F	MAIS 3+F	MAIS 4+F	MAIS 5+F	Fatal
2010	Acura MDX	1696	0.980	0.712	0.491	0.358	0.329	0.296
2010	Acura MDX	1283	0.963	0.590	0.345	0.205	0.179	0.150
2010	Acura MDX	1100	0.949	0.519	0.272	0.141	0.119	0.094
2010	Acura MDX	785	0.903	0.362	0.144	0.051	0.040	0.027
2010	Acura MDX	550	0.827	0.220	0.061	0.013	0.009	0.005
2005	Chevrolet Silverado	1274	0.962	0.587	0.341	0.202	0.176	0.147
2005	Chevrolet Silverado	1133	0.952	0.532	0.285	0.152	0.129	0.103
2005	Chevrolet Silverado	1048	0.943	0.496	0.251	0.124	0.103	0.080
2005	Chevrolet Silverado	929	0.928	0.439	0.202	0.088	0.071	0.053
2005	Chevrolet Silverado	889	0.922	0.419	0.185	0.077	0.061	0.045
2005	Chevrolet Silverado	864	0.918	0.406	0.175	0.070	0.056	0.040
2005	Chevrolet Silverado	833	0.912	0.389	0.163	0.062	0.049	0.035
2005	Chevrolet Silverado	740	0.892	0.337	0.127	0.042	0.032	0.021
2016	Chevrolet Tahoe	2320	0.991	0.823	0.656	0.561	0.536	0.512
2016	Chevrolet Tahoe	2122	0.989	0.795	0.611	0.503	0.475	0.448
2016	Chevrolet Tahoe	1622	0.978	0.693	0.467	0.331	0.302	0.269
2016	Chevrolet Tahoe	1502	0.974	0.661	0.426	0.287	0.258	0.225
2016	Chevrolet Tahoe	1050	0.943	0.497	0.251	0.125	0.104	0.081
2016	Chevrolet Tahoe	979	0.935	0.464	0.222	0.102	0.084	0.064
2016	Chevrolet Tahoe	764	0.898	0.351	0.136	0.047	0.036	0.024
2016	Chevrolet Tahoe	615	0.854	0.261	0.082	0.021	0.015	0.009
2016	Chevrolet Tahoe	611	0.853	0.259	0.081	0.020	0.015	0.009
2016	Chevrolet Tahoe	506	0.806	0.192	0.049	0.009	0.006	0.003
2016	Chevrolet Tahoe	398	0.734	0.124	0.024	0.003	0.002	0.001
1999	Dodge Dakota	2276	0.991	0.817	0.646	0.549	0.523	0.498
1999	Dodge Dakota	1737	0.981	0.721	0.504	0.373	0.344	0.311
1999	Dodge Dakota	1658	0.979	0.702	0.479	0.345	0.315	0.282
1999	Dodge Dakota	1483	0.973	0.655	0.419	0.280	0.251	0.219
1999	Dodge Dakota	1203	0.957	0.561	0.313	0.177	0.152	0.124
1999	Dodge Dakota	859	0.917	0.403	0.173	0.069	0.055	0.039
1999	Dodge Dakota	763	0.898	0.350	0.135	0.047	0.036	0.024
1999	Dodge Dakota	448	0.771	0.155	0.034	0.005	0.003	0.002

2006	Dodge Durango	1766	0.982	0.728	0.513	0.384	0.354	0.322
2006	Dodge Durango	1685	0.980	0.709	0.488	0.354	0.325	0.292
2006	Dodge Durango	1032	0.942	0.489	0.244	0.119	0.099	0.076
2006	Dodge Durango	981	0.935	0.465	0.223	0.103	0.085	0.064
2006	Dodge Durango	769	0.899	0.353	0.138	0.048	0.037	0.025
2006	Dodge Durango	729	0.889	0.330	0.122	0.040	0.030	0.020
2006	Dodge Durango	476	0.788	0.173	0.041	0.007	0.005	0.002
2006	Dodge Durango	343	0.683	0.092	0.015	0.001	0.001	0.000
2003	Dodge Ram	1321	0.965	0.604	0.360	0.219	0.193	0.162
2003	Dodge Ram	1193	0.956	0.557	0.309	0.173	0.149	0.121
2003	Dodge Ram	626	0.858	0.268	0.086	0.022	0.016	0.010
2003	Dodge Ram	614	0.854	0.260	0.081	0.021	0.015	0.009
2003	Dodge Ram	555	0.830	0.223	0.063	0.014	0.010	0.005
2003	Ford E350	3993	0.998	0.942	0.872	0.853	0.845	0.844
2003	Ford E350	2448	0.992	0.839	0.682	0.596	0.572	0.551
2003	Ford E350	1433	0.971	0.640	0.401	0.261	0.233	0.201
2003	Ford E350	1422	0.970	0.637	0.397	0.257	0.229	0.197
2003	Ford E350	1394	0.969	0.628	0.387	0.246	0.219	0.187
2003	Ford E350	1321	0.965	0.604	0.360	0.219	0.193	0.162
2003	Ford E350	1297	0.964	0.595	0.350	0.211	0.184	0.154
2003	Ford E350	868	0.919	0.408	0.177	0.071	0.057	0.041
2016	Ford Edge	1297	0.964	0.595	0.350	0.211	0.184	0.154
2016	Ford Edge	1079	0.946	0.510	0.263	0.134	0.113	0.088
2016	Ford Edge	822	0.910	0.383	0.158	0.060	0.047	0.033
2016	Ford Edge	805	0.907	0.374	0.152	0.056	0.043	0.030
2016	Ford Edge	792	0.904	0.366	0.147	0.053	0.041	0.028
2016	Ford Edge	740	0.892	0.337	0.127	0.042	0.032	0.021
2016	Ford Edge	543	0.824	0.216	0.059	0.013	0.009	0.005
2016	Ford Edge	524	0.815	0.204	0.054	0.011	0.007	0.004
2016	Ford Edge	467	0.783	0.167	0.039	0.006	0.004	0.002
2001	Ford Escape	2292	0.991	0.819	0.650	0.553	0.528	0.503
2001	Ford Escape	1230	0.959	0.571	0.324	0.186	0.161	0.133
2001	Ford Escape	1131	0.951	0.532	0.284	0.151	0.129	0.103
2001	Ford Escape	948	0.931	0.449	0.210	0.093	0.076	0.057
2001	Ford Escape	839	0.913	0.392	0.165	0.064	0.050	0.036
2001	Ford Escape	708	0.884	0.318	0.115	0.036	0.027	0.017
2001	Ford Escape	406	0.740	0.129	0.025	0.003	0.002	0.001
2015	Ford F-150	3163	0.996	0.902	0.794	0.747	0.732	0.722
2015	Ford F-150	2576	0.993	0.853	0.706	0.628	0.606	0.587
2015	Ford F-150	1862	0.984	0.748	0.541	0.417	0.388	0.357
2015	Ford F-150	1121	0.950	0.527	0.280	0.148	0.126	0.100

2015	Ford F-150	1070	0.946	0.506	0.260	0.131	0.110	0.086
2015	Ford F-150	1043	0.943	0.494	0.249	0.122	0.102	0.079
2015	Ford F-150	999	0.938	0.473	0.230	0.108	0.089	0.068
2015	Ford F-150	575	0.838	0.236	0.069	0.016	0.011	0.006
2011	Ford Ranger (Aluminum)	1541	0.975	0.672	0.440	0.301	0.272	0.240
2011	Ford Ranger (Aluminum)	1117	0.950	0.526	0.279	0.147	0.124	0.099
2011	Ford Ranger (Aluminum)	351	0.691	0.096	0.016	0.002	0.001	0.000
2011	Ford Ranger (Steel)	1602	0.977	0.688	0.461	0.324	0.295	0.262
2011	Ford Ranger (Steel)	1033	0.942	0.489	0.244	0.119	0.099	0.076
2011	Ford Ranger (Steel)	751	0.895	0.343	0.131	0.044	0.034	0.023
2004	GMC Savana	984	0.936	0.466	0.224	0.104	0.085	0.065
2004	GMC Savana	585	0.843	0.242	0.072	0.017	0.012	0.007
2004	GMC Savana	582	0.841	0.240	0.071	0.017	0.012	0.007
2004	GMC Savana	524	0.815	0.204	0.054	0.011	0.007	0.004
2005	Honda CRV	1660	0.979	0.703	0.480	0.345	0.316	0.283
2005	Honda CRV	1224	0.959	0.569	0.322	0.184	0.159	0.131
2005	Honda CRV	1197	0.957	0.558	0.311	0.174	0.150	0.122
2005	Honda CRV	1054	0.944	0.498	0.253	0.126	0.105	0.082
2005	Honda CRV	1013	0.939	0.480	0.236	0.113	0.093	0.072
2005	Honda CRV	938	0.930	0.444	0.205	0.090	0.073	0.054
2005	Honda CRV	749	0.894	0.342	0.130	0.044	0.033	0.022
2005	Honda CRV	671	0.873	0.296	0.101	0.029	0.022	0.014
2011	Honda Odyssey	1358	0.967	0.616	0.374	0.233	0.206	0.175
2011	Honda Odyssey	1302	0.964	0.597	0.352	0.212	0.186	0.156
2011	Honda Odyssey	1129	0.951	0.531	0.284	0.151	0.128	0.102
2011	Honda Odyssey	731	0.890	0.331	0.123	0.040	0.030	0.020
2003	Hummer H2	6773	1.000	0.986	0.968	0.973	0.972	0.975
2003	Hummer H2	4594	0.999	0.959	0.907	0.900	0.895	0.897
2003	Hummer H2	4252	0.999	0.950	0.889	0.875	0.869	0.869
2003	Hummer H2	2307	0.991	0.822	0.653	0.557	0.532	0.508
2003	Hummer H2	1493	0.973	0.658	0.423	0.283	0.255	0.222
2003	Hummer H2	1220	0.958	0.567	0.320	0.183	0.158	0.129
2003	Hummer H2	1220	0.958	0.567	0.320	0.183	0.158	0.129
2003	Hummer H2	909	0.925	0.429	0.194	0.082	0.066	0.048
2010	Hyundai Tucson	1484	0.973	0.655	0.420	0.280	0.251	0.219
2010	Hyundai Tucson	1036	0.942	0.490	0.246	0.120	0.100	0.077

2010	Hyundai Tucson	638	0.862	0.275	0.090	0.024	0.018	0.011
2010	Hyundai Tucson	461	0.779	0.163	0.037	0.006	0.004	0.002
2011	Jeep Grand Cherokee	979	0.935	0.464	0.222	0.102	0.084	0.064
2011	Jeep Grand Cherokee	877	0.920	0.413	0.181	0.074	0.059	0.042
2011	Jeep Grand Cherokee	651	0.867	0.283	0.094	0.026	0.019	0.012
2011	Jeep Grand Cherokee	491	0.797	0.182	0.045	0.008	0.005	0.003
2002	Jeep Wrangler	4302	0.999	0.951	0.892	0.879	0.873	0.874
2002	Jeep Wrangler	3574	0.997	0.925	0.838	0.807	0.795	0.791
2002	Jeep Wrangler	2902	0.995	0.883	0.759	0.699	0.681	0.668
2002	Jeep Wrangler	1699	0.980	0.712	0.492	0.360	0.330	0.298
2002	Jeep Wrangler	1697	0.980	0.712	0.492	0.359	0.329	0.297
2002	Jeep Wrangler	553	0.829	0.222	0.062	0.014	0.009	0.005
2002	Jeep Wrangler	456	0.776	0.160	0.036	0.006	0.004	0.002
2002	Jeep Wrangler	379	0.717	0.113	0.020	0.002	0.001	0.001
2016	Nissan Rogue	1096	0.948	0.517	0.270	0.140	0.118	0.093
2016	Nissan Rogue	1074	0.946	0.507	0.261	0.132	0.111	0.087
2016	Nissan Rogue	715	0.886	0.322	0.117	0.037	0.028	0.018
2016	Nissan Rogue	690	0.879	0.307	0.108	0.033	0.024	0.015
2016	Nissan Rogue	566	0.835	0.230	0.066	0.015	0.010	0.006
2016	Nissan Rogue	563	0.833	0.228	0.065	0.015	0.010	0.006
2016	Nissan Rogue	532	0.819	0.209	0.056	0.012	0.008	0.004
2016	Nissan Rogue	423	0.753	0.140	0.029	0.004	0.003	0.001
2020	Subaru Outback	1077	0.946	0.509	0.262	0.133	0.112	0.088
2020	Subaru Outback	1055	0.944	0.499	0.254	0.126	0.106	0.082
2020	Subaru Outback	1023	0.941	0.484	0.240	0.116	0.096	0.074
2020	Subaru Outback	992	0.937	0.470	0.227	0.106	0.087	0.066
2020	Subaru Outback	758	0.896	0.347	0.133	0.045	0.035	0.023
2020	Subaru Outback	741	0.893	0.338	0.127	0.042	0.032	0.021
2020	Subaru Outback	719	0.887	0.324	0.119	0.038	0.028	0.019
2020	Subaru Outback	612	0.853	0.259	0.081	0.021	0.015	0.009
2020	Subaru Outback	545	0.825	0.217	0.060	0.013	0.009	0.005
2020	Subaru Outback	441	0.766	0.151	0.033	0.005	0.003	0.002
2020	Subaru Outback	418	0.749	0.136	0.028	0.004	0.002	0.001
2020	Subaru Outback	329	0.669	0.084	0.013	0.001	0.001	0.000
2020	Subaru Outback	305	0.641	0.071	0.010	0.001	0.000	0.000
2003	Toyota 4-Runner	2288	0.991	0.819	0.649	0.552	0.527	0.502
2003	Toyota 4-Runner	1774	0.982	0.729	0.515	0.386	0.357	0.325
2003	Toyota 4-Runner	1756	0.982	0.725	0.510	0.380	0.351	0.318

2003	Toyota 4-Runner	1344	0.966	0.611	0.368	0.228	0.201	0.170
2003	Toyota 4-Runner	838	0.913	0.392	0.165	0.064	0.050	0.035
2003	Toyota 4-Runner	732	0.890	0.332	0.124	0.040	0.031	0.020
2003	Toyota 4-Runner	580	0.841	0.239	0.071	0.017	0.012	0.007
2003	Toyota 4-Runner	356	0.696	0.099	0.017	0.002	0.001	0.000
2004	Toyota Sienna	1363	0.967	0.618	0.375	0.235	0.207	0.176
2016	Toyota Sienna	1319	0.965	0.603	0.359	0.219	0.192	0.162
2016	Toyota Sienna	1250	0.961	0.578	0.332	0.193	0.168	0.139
2016	Toyota Sienna	1209	0.958	0.563	0.316	0.179	0.154	0.126
2016	Toyota Sienna	909	0.925	0.429	0.194	0.082	0.066	0.048
2016	Toyota Sienna	839	0.913	0.392	0.165	0.064	0.050	0.036
2016	Toyota Sienna	705	0.883	0.316	0.113	0.035	0.026	0.017
2016	Toyota Sienna	655	0.868	0.286	0.095	0.027	0.020	0.012
2004	Toyota Sienna	598	0.848	0.250	0.076	0.019	0.013	0.008
2016	Toyota Sienna	596	0.847	0.249	0.076	0.018	0.013	0.008
2004	Toyota Sienna	518	0.812	0.200	0.052	0.010	0.007	0.004
2004	Toyota Sienna	403	0.738	0.127	0.025	0.003	0.002	0.001
2004	Toyota Sienna	353	0.693	0.098	0.016	0.002	0.001	0.000
2006	Toyota Tacoma	1814	0.983	0.738	0.527	0.401	0.371	0.340
2006	Toyota Tacoma	1443	0.971	0.643	0.405	0.265	0.236	0.204
2006	Toyota Tacoma	1385	0.968	0.625	0.384	0.243	0.215	0.184
2006	Toyota Tacoma	947	0.931	0.448	0.209	0.093	0.076	0.056
2006	Toyota Tacoma	889	0.922	0.419	0.185	0.077	0.061	0.045
2006	Toyota Tacoma	513	0.809	0.197	0.051	0.010	0.007	0.004
2006	Toyota Tacoma	415	0.747	0.135	0.027	0.004	0.002	0.001
2006	Toyota Tacoma	309	0.645	0.073	0.010	0.001	0.000	0.000
Average		**1151.19**	**0.904**	**0.456**	**0.260**	**0.169**	**0.153**	**0.137**

Table 149: FMVSS No. 228 Probability of Fatal and Non-Fatal Injuries for LTV

Year	Vehicle	Within HIC1000	Treated HIC	MAIS 1+F	MAIS 2+F	MAIS 3+F	MAIS 4+F	MAIS 5+F	Fatal
2010	Acura MDX	No	1696	0.980	0.712	0.491	0.358	0.329	0.296
2010	Acura MDX	No	1283	0.963	0.590	0.345	0.205	0.179	0.150
2010	Acura MDX	No	1100	0.949	0.519	0.272	0.141	0.119	0.094
2010	Acura MDX	No	785	0.903	0.362	0.144	0.051	0.040	0.027
2010	Acura MDX	Yes	550	0.827	0.220	0.061	0.013	0.009	0.005
2005	Chevrolet Silverado	No	1274	0.962	0.587	0.341	0.202	0.176	0.147
2005	Chevrolet Silverado	No	1133	0.952	0.532	0.285	0.152	0.129	0.103
2005	Chevrolet Silverado	No	1048	0.943	0.496	0.251	0.124	0.103	0.080

2005	Chevrolet Silverado	No	929	0.928	0.439	0.202	0.088	0.071	0.053
2005	Chevrolet Silverado	No	889	0.922	0.419	0.185	0.077	0.061	0.045
2005	Chevrolet Silverado	Yes	864	0.918	0.406	0.175	0.070	0.056	0.040
2005	Chevrolet Silverado	Yes	833	0.912	0.389	0.163	0.062	0.049	0.035
2005	Chevrolet Silverado	Yes	740	0.892	0.337	0.127	0.042	0.032	0.021
2016	Chevrolet Tahoe	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2016	Chevrolet Tahoe	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2016	Chevrolet Tahoe	No	1502	0.974	0.661	0.426	0.287	0.258	0.225
2016	Chevrolet Tahoe	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2016	Chevrolet Tahoe	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2016	Chevrolet Tahoe	Yes	979	0.935	0.464	0.222	0.102	0.084	0.064
2016	Chevrolet Tahoe	Yes	764	0.898	0.351	0.136	0.047	0.036	0.024
2016	Chevrolet Tahoe	No	615	0.854	0.261	0.082	0.021	0.015	0.009
2016	Chevrolet Tahoe	Yes	611	0.853	0.259	0.081	0.020	0.015	0.009
2016	Chevrolet Tahoe	Yes	506	0.806	0.192	0.049	0.009	0.006	0.003
2016	Chevrolet Tahoe	Yes	398	0.734	0.124	0.024	0.003	0.002	0.001
1999	Dodge Dakota	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
1999	Dodge Dakota	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
1999	Dodge Dakota	No	1658	0.979	0.702	0.479	0.345	0.315	0.282
1999	Dodge Dakota	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
1999	Dodge Dakota	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
1999	Dodge Dakota	Yes	859	0.917	0.403	0.173	0.069	0.055	0.039
1999	Dodge Dakota	Yes	763	0.898	0.350	0.135	0.047	0.036	0.024
1999	Dodge Dakota	Yes	448	0.771	0.155	0.034	0.005	0.003	0.002
2006	Dodge Durango	No	1685	0.980	0.709	0.488	0.354	0.325	0.292
2006	Dodge Durango	No	1032	0.942	0.489	0.244	0.119	0.099	0.076
2006	Dodge Durango	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2006	Dodge Durango	Yes	981	0.935	0.465	0.223	0.103	0.085	0.064
2006	Dodge Durango	Yes	769	0.899	0.353	0.138	0.048	0.037	0.025
2006	Dodge Durango	Yes	729	0.889	0.330	0.122	0.040	0.030	0.020
2006	Dodge Durango	Yes	476	0.788	0.173	0.041	0.007	0.005	0.002
2006	Dodge Durango	Yes	343	0.683	0.092	0.015	0.001	0.001	0.000
2003	Dodge Ram	No	1321	0.965	0.604	0.360	0.219	0.193	0.162
2003	Dodge Ram	No	1193	0.956	0.557	0.309	0.173	0.149	0.121
2003	Dodge Ram	Yes	626	0.858	0.268	0.086	0.022	0.016	0.010
2003	Dodge Ram	Yes	614	0.854	0.260	0.081	0.021	0.015	0.009

2003	Dodge Ram	Yes	555	0.830	0.223	0.063	0.014	0.010	0.005
2003	Ford E350	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2003	Ford E350	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Ford E350	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Ford E350	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Ford E350	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Ford E350	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Ford E350	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Ford E350	Yes	868	0.919	0.408	0.177	0.071	0.057	0.041
2016	Ford Edge	No	1297	0.964	0.595	0.350	0.211	0.184	0.154
2016	Ford Edge	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2016	Ford Edge	No	822	0.910	0.383	0.158	0.060	0.047	0.033
2016	Ford Edge	No	805	0.907	0.374	0.152	0.056	0.043	0.030
2016	Ford Edge	No	792	0.904	0.366	0.147	0.053	0.041	0.028
2016	Ford Edge	Yes	740	0.892	0.337	0.127	0.042	0.032	0.021
2016	Ford Edge	Yes	543	0.824	0.216	0.059	0.013	0.009	0.005
2016	Ford Edge	Yes	524	0.815	0.204	0.054	0.011	0.007	0.004
2016	Ford Edge	Yes	467	0.783	0.167	0.039	0.006	0.004	0.002
2001	Ford Escape	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2001	Ford Escape	No	1131	0.951	0.532	0.284	0.151	0.129	0.103
2001	Ford Escape	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2001	Ford Escape	No	948	0.931	0.449	0.210	0.093	0.076	0.057
2001	Ford Escape	Yes	839	0.913	0.392	0.165	0.064	0.050	0.036
2001	Ford Escape	Yes	708	0.884	0.318	0.115	0.036	0.027	0.017
2001	Ford Escape	Yes	406	0.740	0.129	0.025	0.003	0.002	0.001
2015	Ford F-150	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2015	Ford F-150	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2015	Ford F-150	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2015	Ford F-150	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2015	Ford F-150	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2015	Ford F-150	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2015	Ford F-150	No	999	0.938	0.473	0.230	0.108	0.089	0.068
2015	Ford F-150	Yes	575	0.838	0.236	0.069	0.016	0.011	0.006
2011	Ford Ranger (Aluminum)	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2011	Ford Ranger (Aluminum)	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2011	Ford Ranger (Aluminum)	Yes	351	0.691	0.096	0.016	0.002	0.001	0.000
2011	Ford Ranger	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068

	(Steel)									
2011	Ford Ranger (Steel)	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2011	Ford Ranger (Steel)	Yes	751	0.895	0.343	0.131	0.044	0.034	0.023
2004	GMC Savana	Yes	984	0.936	0.466	0.224	0.104	0.085	0.065
2004	GMC Savana	Yes	585	0.843	0.242	0.072	0.017	0.012	0.007
2004	GMC Savana	Yes	582	0.841	0.240	0.071	0.017	0.012	0.007
2004	GMC Savana	Yes	524	0.815	0.204	0.054	0.011	0.007	0.004
2005	Honda CRV	No	1660	0.979	0.703	0.480	0.345	0.316	0.283
2005	Honda CRV	No	1197	0.957	0.558	0.311	0.174	0.150	0.122
2005	Honda CRV	No	1054	0.944	0.498	0.253	0.126	0.105	0.082
2005	Honda CRV	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2005	Honda CRV	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2005	Honda CRV	Yes	938	0.930	0.444	0.205	0.090	0.073	0.054
2005	Honda CRV	No	749	0.894	0.342	0.130	0.044	0.033	0.022
2005	Honda CRV	No	671	0.873	0.296	0.101	0.029	0.022	0.014
2011	Honda Odyssey	No	1358	0.967	0.616	0.374	0.233	0.206	0.175
2011	Honda Odyssey	No	1302	0.964	0.597	0.352	0.212	0.186	0.156
2011	Honda Odyssey	No	1129	0.951	0.531	0.284	0.151	0.128	0.102
2011	Honda Odyssey	Yes	731	0.890	0.331	0.123	0.040	0.030	0.020
2003	Hummer H2	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2003	Hummer H2	No	1493	0.973	0.658	0.423	0.283	0.255	0.222
2003	Hummer H2	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Hummer H2	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Hummer H2	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Hummer H2	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Hummer H2	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Hummer H2	Yes	909	0.925	0.429	0.194	0.082	0.066	0.048
2010	Hyundai Tucson	No	1484	0.973	0.655	0.420	0.280	0.251	0.219
2010	Hyundai Tucson	No	1036	0.942	0.490	0.246	0.120	0.100	0.077
2010	Hyundai Tucson	No	638	0.862	0.275	0.090	0.024	0.018	0.011
2010	Hyundai Tucson	No	461	0.779	0.163	0.037	0.006	0.004	0.002
2011	Jeep Grand Cherokee	No	979	0.935	0.464	0.222	0.102	0.084	0.064
2011	Jeep Grand Cherokee	No	877	0.920	0.413	0.181	0.074	0.059	0.042
2011	Jeep Grand Cherokee	No	651	0.867	0.283	0.094	0.026	0.019	0.012
2011	Jeep Grand Cherokee	Yes	491	0.797	0.182	0.045	0.008	0.005	0.003

2002	Jeep Wrangler	No	1697	0.980	0.712	0.492	0.359	0.329	0.297
2002	Jeep Wrangler	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2002	Jeep Wrangler	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2002	Jeep Wrangler	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2002	Jeep Wrangler	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2002	Jeep Wrangler	Yes	553	0.829	0.222	0.062	0.014	0.009	0.005
2002	Jeep Wrangler	Yes	456	0.776	0.160	0.036	0.006	0.004	0.002
2002	Jeep Wrangler	Yes	379	0.717	0.113	0.020	0.002	0.001	0.001
2016	Nissan Rogue	No	1096	0.948	0.517	0.270	0.140	0.118	0.093
2016	Nissan Rogue	No	1074	0.946	0.507	0.261	0.132	0.111	0.087
2016	Nissan Rogue	No	715	0.886	0.322	0.117	0.037	0.028	0.018
2016	Nissan Rogue	Yes	690	0.879	0.307	0.108	0.033	0.024	0.015
2016	Nissan Rogue	Yes	566	0.835	0.230	0.066	0.015	0.010	0.006
2016	Nissan Rogue	No	563	0.833	0.228	0.065	0.015	0.010	0.006
2016	Nissan Rogue	Yes	532	0.819	0.209	0.056	0.012	0.008	0.004
2016	Nissan Rogue	Yes	423	0.753	0.140	0.029	0.004	0.003	0.001
2020	Subaru Outback	No	1077	0.946	0.509	0.262	0.133	0.112	0.088
2020	Subaru Outback	No	1055	0.944	0.499	0.254	0.126	0.106	0.082
2020	Subaru Outback	No	1023	0.941	0.484	0.240	0.116	0.096	0.074
2020	Subaru Outback	No	992	0.937	0.470	0.227	0.106	0.087	0.066
2020	Subaru Outback	No	758	0.896	0.347	0.133	0.045	0.035	0.023
2020	Subaru Outback	Yes	741	0.893	0.338	0.127	0.042	0.032	0.021
2020	Subaru Outback	No	719	0.887	0.324	0.119	0.038	0.028	0.019
2020	Subaru Outback	Yes	612	0.853	0.259	0.081	0.021	0.015	0.009
2020	Subaru Outback	Yes	545	0.825	0.217	0.060	0.013	0.009	0.005
2020	Subaru Outback	Yes	441	0.766	0.151	0.033	0.005	0.003	0.002
2020	Subaru Outback	Yes	418	0.749	0.136	0.028	0.004	0.002	0.001
2020	Subaru Outback	Yes	329	0.669	0.084	0.013	0.001	0.001	0.000
2020	Subaru Outback	Yes	305	0.641	0.071	0.010	0.001	0.000	0.000
2003	Toyota 4-Runner	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2003	Toyota 4-Runner	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2003	Toyota 4-Runner	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2003	Toyota 4-Runner	No	1344	0.966	0.611	0.368	0.228	0.201	0.170
2003	Toyota 4-Runner	Yes	838	0.913	0.392	0.165	0.064	0.050	0.035
2003	Toyota 4-Runner	Yes	732	0.890	0.332	0.124	0.040	0.031	0.020
2003	Toyota 4-Runner	Yes	580	0.841	0.239	0.071	0.017	0.012	0.007
2003	Toyota 4-Runner	Yes	356	0.696	0.099	0.017	0.002	0.001	0.000
2004	Toyota Sienna	No	1363	0.967	0.618	0.375	0.235	0.207	0.176
2016	Toyota Sienna	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068

2016	Toyota Sienna	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2016	Toyota Sienna	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2016	Toyota Sienna	No	909	0.925	0.429	0.194	0.082	0.066	0.048
2016	Toyota Sienna	Yes	839	0.913	0.392	0.165	0.064	0.050	0.036
2016	Toyota Sienna	Yes	705	0.883	0.316	0.113	0.035	0.026	0.017
2016	Toyota Sienna	No	655	0.868	0.286	0.095	0.027	0.020	0.012
2004	Toyota Sienna	Yes	598	0.848	0.250	0.076	0.019	0.013	0.008
2016	Toyota Sienna	Yes	596	0.847	0.249	0.076	0.018	0.013	0.008
2004	Toyota Sienna	No	518	0.812	0.200	0.052	0.010	0.007	0.004
2004	Toyota Sienna	Yes	403	0.738	0.127	0.025	0.003	0.002	0.001
2004	Toyota Sienna	Yes	353	0.693	0.098	0.016	0.002	0.001	0.000
2006	Toyota Tacoma	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2006	Toyota Tacoma	No	1443	0.971	0.643	0.405	0.265	0.236	0.204
2006	Toyota Tacoma	No	1385	0.968	0.625	0.384	0.243	0.215	0.184
2006	Toyota Tacoma	No	947	0.931	0.448	0.209	0.093	0.076	0.056
2006	Toyota Tacoma	No	889	0.922	0.419	0.185	0.077	0.061	0.045
2006	Toyota Tacoma	Yes	513	0.809	0.197	0.051	0.010	0.007	0.004
2006	Toyota Tacoma	Yes	415	0.747	0.135	0.027	0.004	0.002	0.001
2006	Toyota Tacoma	Yes	309	0.645	0.073	0.010	0.001	0.000	0.000
Average			**929.77**	**0.897**	**0.413**	**0.206**	**0.110**	**0.095**	**0.078**

Table 150: FMVSS No. 228: Percentage Change in Probability of Fatal and Non-Fatal Injury for LTV

Injury Severity	**Baseline**	**Treated**	**Percentage Change**
MAIS 1+F	0.904	0.897	0.7%
MAIS 2+F	0.456	0.413	9.5%
MAIS 3+F	0.260	0.206	20.8%
MAIS 4+F	0.169	0.110	34.9%
MAIS 5+F	0.153	0.095	38.2%
Fatalities	0.137	0.078	43.0%

12.7. Appendix G: Calculations for Regulatory Alternatives

Table 151: Regulatory Option #1: EU Interpretation of GTR 9 Probability of Fatal and Non-Fatal Injuries for Passenger Cars

Year	**Vehicle**	**Within HIC1000**	**Treated HIC**	**MAIS 1+F**	**MAIS 2+F**	**MAIS 3+F**	**MAIS 4+F**	**MAIS 5+F**	**Fatal**
2017	Audi A4	No	1153	0.953	0.541	0.293	0.159	0.136	0.109
2017	Audi A4	No	1085	0.947	0.512	0.266	0.136	0.114	0.090
2017	Audi A4	No	1053	0.944	0.498	0.253	0.125	0.105	0.082

2017	Audi A4	Yes	945	0.931	0.447	0.208	0.092	0.075	0.056
2017	Audi A4	No	875	0.920	0.412	0.180	0.073	0.058	0.042
2017	Audi A4	Yes	795	0.905	0.368	0.148	0.054	0.042	0.029
2017	Audi A4	No	766	0.898	0.352	0.137	0.047	0.036	0.024
2017	Audi A4	Yes	703	0.882	0.315	0.113	0.035	0.026	0.017
2017	Audi A4	Yes	698	0.881	0.312	0.111	0.034	0.025	0.016
2017	Audi A4	Yes	621	0.856	0.265	0.084	0.022	0.016	0.009
2017	Audi A4	Yes	556	0.830	0.224	0.063	0.014	0.010	0.005
2017	Audi A4	No	450	0.772	0.157	0.035	0.005	0.003	0.002
2010	Buick Lacrosse	No	1602	0.977	0.688	0.461	0.324	0.295	0.262
2010	Buick Lacrosse	No	1026	0.941	0.486	0.242	0.117	0.097	0.075
2010	Buick Lacrosse	No	686	0.878	0.305	0.107	0.032	0.024	0.015
2018	Buick Regal	No	1204	0.957	0.561	0.314	0.177	0.152	0.124
2018	Buick Regal	Yes	905	0.925	0.427	0.192	0.081	0.065	0.048
2018	Buick Regal	No	834	0.913	0.390	0.163	0.063	0.049	0.035
2018	Buick Regal	No	817	0.909	0.380	0.157	0.059	0.046	0.032
2018	Buick Regal	No	673	0.874	0.297	0.102	0.030	0.022	0.014
2018	Buick Regal	No	641	0.863	0.277	0.091	0.025	0.018	0.011
2018	Buick Regal	No	574	0.838	0.235	0.069	0.016	0.011	0.006
2018	Buick Regal	No	452	0.773	0.158	0.035	0.006	0.004	0.002
2018	Buick Regal	Yes	396	0.732	0.123	0.023	0.003	0.002	0.001
2017	Cadillac ATS	No	1923	0.986	0.760	0.559	0.438	0.409	0.379
2017	Cadillac ATS	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2017	Cadillac ATS	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2017	Cadillac ATS	No	400	0.735	0.125	0.024	0.003	0.002	0.001
2017	Cadillac ATS	Yes	299	0.633	0.068	0.009	0.001	0.000	0.000
2017	Cadillac ATS	No	232	0.536	0.037	0.003	0.000	0.000	0.000
2016	Chevrolet Malibu	No	1470	0.972	0.651	0.415	0.275	0.246	0.214
2016	Chevrolet Malibu	No	1203	0.957	0.561	0.313	0.177	0.152	0.124
2016	Chevrolet Malibu	No	1107	0.949	0.522	0.275	0.143	0.121	0.096
2016	Chevrolet Malibu	No	1096	0.948	0.517	0.270	0.140	0.118	0.093

2016	Chevrolet Malibu	No	1013	0.939	0.480	0.236	0.113	0.093	0.071
2016	Chevrolet Malibu	Yes	864	0.918	0.406	0.175	0.070	0.056	0.040
2016	Chevrolet Malibu	No	768	0.899	0.353	0.137	0.048	0.037	0.025
2016	Chevrolet Malibu	Yes	762	0.897	0.349	0.135	0.046	0.036	0.024
2016	Chevrolet Malibu	No	761	0.897	0.349	0.135	0.046	0.035	0.024
2016	Chevrolet Malibu	Yes	703	0.882	0.315	0.113	0.035	0.026	0.017
2016	Chevrolet Malibu	Yes	589	0.844	0.245	0.073	0.018	0.012	0.007
2016	Chevrolet Malibu	Yes	514	0.810	0.197	0.051	0.010	0.007	0.004
2016	Chevrolet Malibu	Yes	397	0.733	0.124	0.024	0.003	0.002	0.001
2016	Chevrolet Malibu	Yes	376	0.715	0.111	0.020	0.002	0.001	0.001
2016	Chevrolet Malibu	Yes	374	0.713	0.110	0.019	0.002	0.001	0.001
2003	Ford Crown Victoria	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2003	Ford Crown Victoria	No	1012	0.939	0.479	0.236	0.112	0.093	0.071
2003	Ford Crown Victoria	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Ford Crown Victoria	No	711	0.885	0.320	0.116	0.036	0.027	0.018
2003	Ford Crown Victoria	No	536	0.821	0.211	0.057	0.012	0.008	0.004
2003	Ford Crown Victoria	Yes	514	0.810	0.197	0.051	0.010	0.007	0.004
2003	Ford Crown Victoria	Yes	481	0.791	0.176	0.042	0.007	0.005	0.002
2003	Ford Crown Victoria	Yes	480	0.791	0.176	0.042	0.007	0.005	0.002
2011	Ford Focus	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2011	Ford Focus	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2011	Ford Focus	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2011	Ford Focus	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2011	Ford Focus	No	684	0.877	0.303	0.106	0.032	0.023	0.015
2011	Ford Focus	Yes	588	0.844	0.244	0.073	0.018	0.012	0.007
1994	Honda Civic	No	1700	0.980	0.712	0.492	0.360	0.330	0.298

1994	Honda Civic	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2001	Honda Civic	No	1005	0.938	0.476	0.233	0.110	0.091	0.070
1994	Honda Civic	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2001	Honda Civic	No	965	0.933	0.457	0.217	0.098	0.080	0.060
2001	Honda Civic	Yes	722	0.888	0.326	0.120	0.038	0.029	0.019
2001	Honda Civic	Yes	683	0.877	0.303	0.105	0.031	0.023	0.015
1994	Honda Civic	No	616	0.855	0.262	0.082	0.021	0.015	0.009
2001	Honda Civic	No	510	0.808	0.195	0.050	0.010	0.006	0.003
1994	Honda Civic	Yes	468	0.784	0.168	0.039	0.006	0.004	0.002
2016	Honda Fit	No	1223	0.959	0.568	0.321	0.184	0.159	0.130
2016	Honda Fit	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2016	Honda Fit	Yes	724	0.888	0.327	0.121	0.039	0.029	0.019
2016	Honda Fit	No	624	0.858	0.267	0.085	0.022	0.016	0.010
2016	Honda Fit	No	431	0.759	0.145	0.031	0.004	0.003	0.001
2016	Honda Fit	Yes	380	0.718	0.113	0.021	0.002	0.001	0.001
2010	Kia Forte	No	1587	0.977	0.684	0.456	0.318	0.289	0.256
2010	Kia Forte	No	626	0.858	0.268	0.086	0.022	0.016	0.010
2010	Kia Forte	No	597	0.847	0.250	0.076	0.019	0.013	0.008
2004	Toyota Camry	No	1701	0.980	0.713	0.493	0.360	0.331	0.298
2004	Toyota Camry	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2004	Toyota Camry	No	733	0.890	0.333	0.124	0.040	0.031	0.020
2004	Toyota Camry	Yes	502	0.803	0.190	0.048	0.009	0.006	0.003
2004	Toyota Camry	Yes	454	0.775	0.159	0.036	0.006	0.004	0.002
2016	Toyota Prius	No	1121	0.950	0.527	0.280	0.148	0.126	0.100
2016	Toyota Prius	No	1021	0.940	0.483	0.240	0.115	0.096	0.073
2016	Toyota Prius	No	999	0.938	0.473	0.230	0.108	0.089	0.068
2016	Toyota Prius	No	793	0.904	0.367	0.147	0.053	0.041	0.028
2016	Toyota Prius	Yes	740	0.892	0.337	0.127	0.042	0.032	0.021
2016	Toyota Prius	Yes	659	0.869	0.288	0.097	0.027	0.020	0.013
2016	Toyota Prius	Yes	495	0.800	0.185	0.046	0.008	0.006	0.003
2016	Toyota Prius	No	449	0.771	0.156	0.035	0.005	0.003	0.002
2016	Toyota Prius	No	366	0.706	0.105	0.018	0.002	0.001	0.000
2016	Toyota Prius	Yes	350	0.690	0.096	0.016	0.002	0.001	0.000
2016	Toyota Prius	No	335	0.675	0.087	0.013	0.001	0.001	0.000
2016	Toyota Prius	No	313	0.650	0.075	0.011	0.001	0.000	0.000
2021	VW Arteon	No	1088	0.947	0.513	0.267	0.137	0.115	0.091
2021	VW Arteon	No	1050	0.944	0.497	0.252	0.125	0.104	0.081

2021	VW Arteon	No	913	0.926	0.431	0.195	0.083	0.067	0.049
2021	VW Arteon	No	835	0.913	0.390	0.164	0.063	0.050	0.035
2021	VW Arteon	No	833	0.912	0.389	0.163	0.062	0.049	0.035
2021	VW Arteon	No	775	0.900	0.357	0.140	0.049	0.038	0.026
2021	VW Arteon	No	708	0.884	0.318	0.115	0.036	0.027	0.017
2021	VW Arteon	No	526	0.816	0.205	0.054	0.011	0.007	0.004
2021	VW Arteon	Yes	505	0.805	0.191	0.048	0.009	0.006	0.003
2021	VW Arteon	No	484	0.793	0.178	0.043	0.008	0.005	0.003
2021	VW Arteon	Yes	467	0.783	0.167	0.039	0.006	0.004	0.002
2021	VW Arteon	Yes	414	0.746	0.134	0.027	0.004	0.002	0.001
2021	VW Arteon	No	411	0.744	0.132	0.026	0.003	0.002	0.001
2021	VW Arteon	Yes	394	0.730	0.122	0.023	0.003	0.002	0.001
2021	VW Arteon	Yes	338	0.678	0.089	0.014	0.001	0.001	0.000
2006	VW Passat	No	1302	0.964	0.597	0.352	0.212	0.186	0.156
2006	VW Passat	No	836	0.913	0.391	0.164	0.063	0.050	0.035
2006	VW Passat	Yes	734	0.891	0.333	0.124	0.041	0.031	0.020
2006	VW Passat	Yes	565	0.834	0.230	0.066	0.015	0.010	0.006
2006	VW Passat	Yes	378	0.717	0.112	0.020	0.002	0.001	0.001
Average			**802.73**	**0.865**	**0.347**	**0.160**	**0.080**	**0.069**	**0.056**

Table 152: Regulatory Option #1: GTR 9 Percentage Change in Probability of Fatal and Non-Fatal Injury for Passenger Cars

Injury Severity	Baseline	Treated	Percentage Change
MAIS 1+F	0.867	0.865	0.3%
MAIS 2+F	0.363	0.347	4.5%
MAIS 3+F	0.181	0.160	11.6%
MAIS 4+F	0.104	0.080	22.7%
MAIS 5+F	0.092	0.069	25.6%
Fatalities	0.080	0.056	30.0%

Table 153: Regulatory Option #1: GTR 9 Probability of Fatal and Non-Fatal Injuries for LTV

Year	Vehicle	Within HIC1000	Treated HIC	MAIS 1+F	MAIS 2+F	MAIS 3+F	MAIS 4+F	MAIS 5+F	Fatal
2010	Acura MDX	No	1696	0.980	0.712	0.491	0.358	0.329	0.296
2010	Acura MDX	No	1283	0.963	0.590	0.345	0.205	0.179	0.150
2010	Acura MDX	No	1100	0.949	0.519	0.272	0.141	0.119	0.094
2010	Acura MDX	No	785	0.903	0.362	0.144	0.051	0.040	0.027
2010	Acura MDX	Yes	550	0.827	0.220	0.061	0.013	0.009	0.005
2005	Chevrolet Silverado	No	1274	0.962	0.587	0.341	0.202	0.176	0.147

2005	Chevrolet Silverado	No	1133	0.952	0.532	0.285	0.152	0.129	0.103
2005	Chevrolet Silverado	No	1048	0.943	0.496	0.251	0.124	0.103	0.080
2005	Chevrolet Silverado	No	929	0.928	0.439	0.202	0.088	0.071	0.053
2005	Chevrolet Silverado	No	889	0.922	0.419	0.185	0.077	0.061	0.045
2005	Chevrolet Silverado	No	864	0.918	0.406	0.175	0.070	0.056	0.040
2005	Chevrolet Silverado	Yes	833	0.912	0.389	0.163	0.062	0.049	0.035
2005	Chevrolet Silverado	Yes	740	0.892	0.337	0.127	0.042	0.032	0.021
2016	Chevrolet Tahoe	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2016	Chevrolet Tahoe	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2016	Chevrolet Tahoe	No	1622	0.978	0.693	0.467	0.331	0.302	0.269
2016	Chevrolet Tahoe	No	1502	0.974	0.661	0.426	0.287	0.258	0.225
2016	Chevrolet Tahoe	No	1050	0.943	0.497	0.251	0.125	0.104	0.081
2016	Chevrolet Tahoe	Yes	979	0.935	0.464	0.222	0.102	0.084	0.064
2016	Chevrolet Tahoe	No	764	0.898	0.351	0.136	0.047	0.036	0.024
2016	Chevrolet Tahoe	No	615	0.854	0.261	0.082	0.021	0.015	0.009
2016	Chevrolet Tahoe	Yes	611	0.853	0.259	0.081	0.020	0.015	0.009
2016	Chevrolet Tahoe	Yes	506	0.806	0.192	0.049	0.009	0.006	0.003
2016	Chevrolet Tahoe	Yes	398	0.734	0.124	0.024	0.003	0.002	0.001
1999	Dodge Dakota	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
1999	Dodge Dakota	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
1999	Dodge Dakota	No	1658	0.979	0.702	0.479	0.345	0.315	0.282
1999	Dodge Dakota	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
1999	Dodge Dakota	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
1999	Dodge Dakota	Yes	859	0.917	0.403	0.173	0.069	0.055	0.039
1999	Dodge Dakota	Yes	763	0.898	0.350	0.135	0.047	0.036	0.024
1999	Dodge Dakota	Yes	448	0.771	0.155	0.034	0.005	0.003	0.002
2006	Dodge Durango	No	1766	0.982	0.728	0.513	0.384	0.354	0.322
2006	Dodge Durango	No	1685	0.980	0.709	0.488	0.354	0.325	0.292
2006	Dodge Durango	No	1032	0.942	0.489	0.244	0.119	0.099	0.076

2006	Dodge Durango	Yes	981	0.935	0.465	0.223	0.103	0.085	0.064
2006	Dodge Durango	Yes	769	0.899	0.353	0.138	0.048	0.037	0.025
2006	Dodge Durango	Yes	729	0.889	0.330	0.122	0.040	0.030	0.020
2006	Dodge Durango	Yes	476	0.788	0.173	0.041	0.007	0.005	0.002
2006	Dodge Durango	Yes	343	0.683	0.092	0.015	0.001	0.001	0.000
2003	Dodge Ram	No	1321	0.965	0.604	0.360	0.219	0.193	0.162
2003	Dodge Ram	No	1193	0.956	0.557	0.309	0.173	0.149	0.121
2003	Dodge Ram	Yes	626	0.858	0.268	0.086	0.022	0.016	0.010
2003	Dodge Ram	Yes	614	0.854	0.260	0.081	0.021	0.015	0.009
2003	Dodge Ram	Yes	555	0.830	0.223	0.063	0.014	0.010	0.005
2003	Ford E350	No	3993	0.998	0.942	0.872	0.853	0.845	0.844
2003	Ford E350	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2003	Ford E350	No	1433	0.971	0.640	0.401	0.261	0.233	0.201
2003	Ford E350	No	1422	0.970	0.637	0.397	0.257	0.229	0.197
2003	Ford E350	No	1394	0.969	0.628	0.387	0.246	0.219	0.187
2003	Ford E350	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Ford E350	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Ford E350	Yes	868	0.919	0.408	0.177	0.071	0.057	0.041
2016	Ford Edge	No	1297	0.964	0.595	0.350	0.211	0.184	0.154
2016	Ford Edge	No	1079	0.946	0.510	0.263	0.134	0.113	0.088
2016	Ford Edge	No	822	0.910	0.383	0.158	0.060	0.047	0.033
2016	Ford Edge	No	805	0.907	0.374	0.152	0.056	0.043	0.030
2016	Ford Edge	No	792	0.904	0.366	0.147	0.053	0.041	0.028
2016	Ford Edge	Yes	740	0.892	0.337	0.127	0.042	0.032	0.021
2016	Ford Edge	Yes	543	0.824	0.216	0.059	0.013	0.009	0.005
2016	Ford Edge	Yes	524	0.815	0.204	0.054	0.011	0.007	0.004
2016	Ford Edge	Yes	467	0.783	0.167	0.039	0.006	0.004	0.002
2001	Ford Escape	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2001	Ford Escape	No	1131	0.951	0.532	0.284	0.151	0.129	0.103
2001	Ford Escape	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2001	Ford Escape	No	948	0.931	0.449	0.210	0.093	0.076	0.057
2001	Ford Escape	Yes	839	0.913	0.392	0.165	0.064	0.050	0.036
2001	Ford Escape	No	708	0.884	0.318	0.115	0.036	0.027	0.017
2001	Ford Escape	Yes	406	0.740	0.129	0.025	0.003	0.002	0.001
2015	Ford F-150	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2015	Ford F-150	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2015	Ford F-150	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2015	Ford F-150	No	1121	0.950	0.527	0.280	0.148	0.126	0.100
2015	Ford F-150	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068

2015	Ford F-150	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2015	Ford F-150	No	999	0.938	0.473	0.230	0.108	0.089	0.068
2015	Ford F-150	Yes	575	0.838	0.236	0.069	0.016	0.011	0.006
2011	Ford Ranger (Aluminum)	No	1117	0.950	0.526	0.279	0.147	0.124	0.099
2011	Ford Ranger (Aluminum)	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2011	Ford Ranger (Aluminum)	Yes	351	0.691	0.096	0.016	0.002	0.001	0.000
2011	Ford Ranger (Steel)	No	1033	0.942	0.489	0.244	0.119	0.099	0.076
2011	Ford Ranger (Steel)	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2011	Ford Ranger (Steel)	Yes	751	0.895	0.343	0.131	0.044	0.034	0.023
2004	GMC Savana	Yes	984	0.936	0.466	0.224	0.104	0.085	0.065
2004	GMC Savana	No	585	0.843	0.242	0.072	0.017	0.012	0.007
2004	GMC Savana	No	582	0.841	0.240	0.071	0.017	0.012	0.007
2004	GMC Savana	Yes	524	0.815	0.204	0.054	0.011	0.007	0.004
2005	Honda CRV	No	1660	0.979	0.703	0.480	0.345	0.316	0.283
2005	Honda CRV	No	1224	0.959	0.569	0.322	0.184	0.159	0.131
2005	Honda CRV	No	1197	0.957	0.558	0.311	0.174	0.150	0.122
2005	Honda CRV	No	1054	0.944	0.498	0.253	0.126	0.105	0.082
2005	Honda CRV	No	1013	0.939	0.480	0.236	0.113	0.093	0.072
2005	Honda CRV	No	938	0.930	0.444	0.205	0.090	0.073	0.054
2005	Honda CRV	No	749	0.894	0.342	0.130	0.044	0.033	0.022
2005	Honda CRV	No	671	0.873	0.296	0.101	0.029	0.022	0.014
2011	Honda Odyssey	No	1358	0.967	0.616	0.374	0.233	0.206	0.175
2011	Honda Odyssey	No	1302	0.964	0.597	0.352	0.212	0.186	0.156
2011	Honda Odyssey	No	1129	0.951	0.531	0.284	0.151	0.128	0.102
2011	Honda Odyssey	Yes	731	0.890	0.331	0.123	0.040	0.030	0.020
2003	Hummer H2	No	6773	1.000	0.986	0.968	0.973	0.972	0.975
2003	Hummer H2	No	4252	0.999	0.950	0.889	0.875	0.869	0.869
2003	Hummer H2	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2003	Hummer H2	No	1493	0.973	0.658	0.423	0.283	0.255	0.222
2003	Hummer H2	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Hummer H2	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Hummer H2	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Hummer H2	Yes	909	0.925	0.429	0.194	0.082	0.066	0.048
2010	Hyundai Tucson	No	1484	0.973	0.655	0.420	0.280	0.251	0.219
2010	Hyundai Tucson	No	1036	0.942	0.490	0.246	0.120	0.100	0.077

2010	Hyundai Tucson	No	638	0.862	0.275	0.090	0.024	0.018	0.011
2010	Hyundai Tucson	No	461	0.779	0.163	0.037	0.006	0.004	0.002
2011	Jeep Grand Cherokee	No	979	0.935	0.464	0.222	0.102	0.084	0.064
2011	Jeep Grand Cherokee	No	877	0.920	0.413	0.181	0.074	0.059	0.042
2011	Jeep Grand Cherokee	No	651	0.867	0.283	0.094	0.026	0.019	0.012
2011	Jeep Grand Cherokee	Yes	491	0.797	0.182	0.045	0.008	0.005	0.003
2002	Jeep Wrangler	No	4302	0.999	0.951	0.892	0.879	0.873	0.874
2002	Jeep Wrangler	No	3574	0.997	0.925	0.838	0.807	0.795	0.791
2002	Jeep Wrangler	No	2902	0.995	0.883	0.759	0.699	0.681	0.668
2002	Jeep Wrangler	No	1697	0.980	0.712	0.492	0.359	0.329	0.297
2002	Jeep Wrangler	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2002	Jeep Wrangler	Yes	553	0.829	0.222	0.062	0.014	0.009	0.005
2002	Jeep Wrangler	Yes	456	0.776	0.160	0.036	0.006	0.004	0.002
2002	Jeep Wrangler	Yes	379	0.717	0.113	0.020	0.002	0.001	0.001
2016	Nissan Rogue	No	1096	0.948	0.517	0.270	0.140	0.118	0.093
2016	Nissan Rogue	No	1074	0.946	0.507	0.261	0.132	0.111	0.087
2016	Nissan Rogue	No	715	0.886	0.322	0.117	0.037	0.028	0.018
2016	Nissan Rogue	Yes	690	0.879	0.307	0.108	0.033	0.024	0.015
2016	Nissan Rogue	Yes	566	0.835	0.230	0.066	0.015	0.010	0.006
2016	Nissan Rogue	No	563	0.833	0.228	0.065	0.015	0.010	0.006
2016	Nissan Rogue	No	532	0.819	0.209	0.056	0.012	0.008	0.004
2016	Nissan Rogue	Yes	423	0.753	0.140	0.029	0.004	0.003	0.001
2020	Subaru Outback	No	1077	0.946	0.509	0.262	0.133	0.112	0.088
2020	Subaru Outback	No	1055	0.944	0.499	0.254	0.126	0.106	0.082
2020	Subaru Outback	No	1023	0.941	0.484	0.240	0.116	0.096	0.074
2020	Subaru Outback	No	992	0.937	0.470	0.227	0.106	0.087	0.066
2020	Subaru Outback	No	758	0.896	0.347	0.133	0.045	0.035	0.023
2020	Subaru Outback	No	741	0.893	0.338	0.127	0.042	0.032	0.021
2020	Subaru Outback	No	719	0.887	0.324	0.119	0.038	0.028	0.019
2020	Subaru Outback	No	612	0.853	0.259	0.081	0.021	0.015	0.009
2020	Subaru Outback	Yes	545	0.825	0.217	0.060	0.013	0.009	0.005

2020	Subaru Outback	Yes	441	0.766	0.151	0.033	0.005	0.003	0.002
2020	Subaru Outback	No	418	0.749	0.136	0.028	0.004	0.002	0.001
2020	Subaru Outback	No	329	0.669	0.084	0.013	0.001	0.001	0.000
2020	Subaru Outback	Yes	305	0.641	0.071	0.010	0.001	0.000	0.000
2003	Toyota 4-Runner	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2003	Toyota 4-Runner	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2003	Toyota 4-Runner	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2003	Toyota 4-Runner	No	1344	0.966	0.611	0.368	0.228	0.201	0.170
2003	Toyota 4-Runner	Yes	838	0.913	0.392	0.165	0.064	0.050	0.035
2003	Toyota 4-Runner	Yes	732	0.890	0.332	0.124	0.040	0.031	0.020
2003	Toyota 4-Runner	Yes	580	0.841	0.239	0.071	0.017	0.012	0.007
2003	Toyota 4-Runner	Yes	356	0.696	0.099	0.017	0.002	0.001	0.000
2004	Toyota Sienna	No	1363	0.967	0.618	0.375	0.235	0.207	0.176
2016	Toyota Sienna	No	1209	0.958	0.563	0.316	0.179	0.154	0.126
2016	Toyota Sienna	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2016	Toyota Sienna	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2016	Toyota Sienna	No	909	0.925	0.429	0.194	0.082	0.066	0.048
2016	Toyota Sienna	No	839	0.913	0.392	0.165	0.064	0.050	0.036
2016	Toyota Sienna	Yes	705	0.883	0.316	0.113	0.035	0.026	0.017
2016	Toyota Sienna	No	655	0.868	0.286	0.095	0.027	0.020	0.012
2004	Toyota Sienna	Yes	598	0.848	0.250	0.076	0.019	0.013	0.008
2016	Toyota Sienna	Yes	596	0.847	0.249	0.076	0.018	0.013	0.008
2004	Toyota Sienna	No	518	0.812	0.200	0.052	0.010	0.007	0.004
2004	Toyota Sienna	Yes	403	0.738	0.127	0.025	0.003	0.002	0.001
2004	Toyota Sienna	Yes	353	0.693	0.098	0.016	0.002	0.001	0.000
2006	Toyota Tacoma	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2006	Toyota Tacoma	No	1443	0.971	0.643	0.405	0.265	0.236	0.204
2006	Toyota Tacoma	No	1385	0.968	0.625	0.384	0.243	0.215	0.184
2006	Toyota Tacoma	No	947	0.931	0.448	0.209	0.093	0.076	0.056
2006	Toyota Tacoma	No	889	0.922	0.419	0.185	0.077	0.061	0.045
2006	Toyota Tacoma	Yes	513	0.809	0.197	0.051	0.010	0.007	0.004
2006	Toyota Tacoma	Yes	415	0.747	0.135	0.027	0.004	0.002	0.001

2006	Toyota Tacoma	Yes	309	0.645	0.073	0.010	0.001	0.000	0.000
Average			**1064.33**	**0.901**	**0.436**	**0.236**	**0.142**	**0.127**	**0.111**

Table 154: Regulatory Option #1: GTR 9 Percentage Change in Probability of Fatal and Non-Fatal Injury for LTV

Injury Severity	Baseline	Treated	Percentage Change
MAIS 1+F	0.904	0.901	0.3%
MAIS 2+F	0.456	0.436	4.3%
MAIS 3+F	0.260	0.236	9.3%
MAIS 4+F	0.169	0.142	15.5%
MAIS 5+F	0.153	0.127	16.9%
Fatalities	0.137	0.111	19.0%

Table 155: Regulatory Option #3: Test Area=Hood Top Probability of Fatal and Non-Fatal Injuries for Passenger Cars

Year	Vehicle	Within HIC 1000	Treated HIC	MAIS 1+F	MAIS 2+F	MAIS 3+F	MAIS 4+F	MAIS 5+F	Fatal
2017	Audi A4	No	1153	0.953	0.541	0.293	0.159	0.136	0.109
2017	Audi A4	No	1085	0.947	0.512	0.266	0.136	0.114	0.090
2017	Audi A4	No	1053	0.944	0.498	0.253	0.125	0.105	0.082
2017	Audi A4	Yes	945	0.931	0.447	0.208	0.092	0.075	0.056
2017	Audi A4	No	875	0.920	0.412	0.180	0.073	0.058	0.042
2017	Audi A4	Yes	795	0.905	0.368	0.148	0.054	0.042	0.029
2017	Audi A4	No	766	0.898	0.352	0.137	0.047	0.036	0.024
2017	Audi A4	Yes	703	0.882	0.315	0.113	0.035	0.026	0.017
2017	Audi A4	Yes	698	0.881	0.312	0.111	0.034	0.025	0.016
2017	Audi A4	Yes	621	0.856	0.265	0.084	0.022	0.016	0.009
2017	Audi A4	Yes	556	0.830	0.224	0.063	0.014	0.010	0.005
2017	Audi A4	No	450	0.772	0.157	0.035	0.005	0.003	0.002
2010	Buick Lacrosse	No	1602	0.977	0.688	0.461	0.324	0.295	0.262
2010	Buick Lacrosse	No	1026	0.941	0.486	0.242	0.117	0.097	0.075
2010	Buick Lacrosse	No	686	0.878	0.305	0.107	0.032	0.024	0.015
2018	Buick Regal	No	1204	0.957	0.561	0.314	0.177	0.152	0.124
2018	Buick Regal	Yes	905	0.925	0.427	0.192	0.081	0.065	0.048

2018	Buick Regal	Yes	834	0.913	0.390	0.163	0.063	0.049	0.035
2018	Buick Regal	No	817	0.909	0.380	0.157	0.059	0.046	0.032
2018	Buick Regal	No	673	0.874	0.297	0.102	0.030	0.022	0.014
2018	Buick Regal	Yes	641	0.863	0.277	0.091	0.025	0.018	0.011
2018	Buick Regal	Yes	574	0.838	0.235	0.069	0.016	0.011	0.006
2018	Buick Regal	Yes	452	0.773	0.158	0.035	0.006	0.004	0.002
2018	Buick Regal	Yes	396	0.732	0.123	0.023	0.003	0.002	0.001
2017	Cadillac ATS	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2017	Cadillac ATS	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2017	Cadillac ATS	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2017	Cadillac ATS	Yes	400	0.735	0.125	0.024	0.003	0.002	0.001
2017	Cadillac ATS	Yes	299	0.633	0.068	0.009	0.001	0.000	0.000
2017	Cadillac ATS	No	232	0.536	0.037	0.003	0.000	0.000	0.000
2016	Chevrolet Malibu	No	1470	0.972	0.651	0.415	0.275	0.246	0.214
2016	Chevrolet Malibu	No	1107	0.949	0.522	0.275	0.143	0.121	0.096
2016	Chevrolet Malibu	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2016	Chevrolet Malibu	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2016	Chevrolet Malibu	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2016	Chevrolet Malibu	Yes	864	0.918	0.406	0.175	0.070	0.056	0.040
2016	Chevrolet	Yes	768	0.899	0.353	0.137	0.048	0.037	0.025

	Malibu								
2016	Chevrolet Malibu	Yes	762	0.897	0.349	0.135	0.046	0.036	0.024
2016	Chevrolet Malibu	Yes	761	0.897	0.349	0.135	0.046	0.035	0.024
2016	Chevrolet Malibu	Yes	703	0.882	0.315	0.113	0.035	0.026	0.017
2016	Chevrolet Malibu	Yes	589	0.844	0.245	0.073	0.018	0.012	0.007
2016	Chevrolet Malibu	Yes	514	0.810	0.197	0.051	0.010	0.007	0.004
2016	Chevrolet Malibu	Yes	397	0.733	0.124	0.024	0.003	0.002	0.001
2016	Chevrolet Malibu	Yes	376	0.715	0.111	0.020	0.002	0.001	0.001
2016	Chevrolet Malibu	Yes	374	0.713	0.110	0.019	0.002	0.001	0.001
2003	Ford Crown Victoria	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2003	Ford Crown Victoria	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Ford Crown Victoria	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Ford Crown Victoria	Yes	711	0.885	0.320	0.116	0.036	0.027	0.018
2003	Ford Crown Victoria	Yes	536	0.821	0.211	0.057	0.012	0.008	0.004
2003	Ford Crown Victoria	Yes	514	0.810	0.197	0.051	0.010	0.007	0.004
2003	Ford Crown Victoria	Yes	481	0.791	0.176	0.042	0.007	0.005	0.002

2003	Ford Crown Victoria	Yes	480	0.791	0.176	0.042	0.007	0.005	0.002
2011	Ford Focus	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2011	Ford Focus	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2011	Ford Focus	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2011	Ford Focus	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2011	Ford Focus	Yes	684	0.877	0.303	0.106	0.032	0.023	0.015
2011	Ford Focus	Yes	588	0.844	0.244	0.073	0.018	0.012	0.007
1994	Honda Civic	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
1994	Honda Civic	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2001	Honda Civic	No	1005	0.938	0.476	0.233	0.110	0.091	0.070
1994	Honda Civic	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2001	Honda Civic	No	965	0.933	0.457	0.217	0.098	0.080	0.060
2001	Honda Civic	Yes	722	0.888	0.326	0.120	0.038	0.029	0.019
2001	Honda Civic	Yes	683	0.877	0.303	0.105	0.031	0.023	0.015
1994	Honda Civic	Yes	616	0.855	0.262	0.082	0.021	0.015	0.009
2001	Honda Civic	Yes	510	0.808	0.195	0.050	0.010	0.006	0.003
1994	Honda Civic	Yes	468	0.784	0.168	0.039	0.006	0.004	0.002
2016	Honda Fit	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2016	Honda Fit	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2016	Honda Fit	Yes	724	0.888	0.327	0.121	0.039	0.029	0.019
2016	Honda Fit	Yes	624	0.858	0.267	0.085	0.022	0.016	0.010
2016	Honda Fit	Yes	431	0.759	0.145	0.031	0.004	0.003	0.001

2016	Honda Fit	Yes	380	0.718	0.113	0.021	0.002	0.001	0.001
2010	Kia Forte	No	1587	0.977	0.684	0.456	0.318	0.289	0.256
2010	Kia Forte	Yes	626	0.858	0.268	0.086	0.022	0.016	0.010
2010	Kia Forte	No	597	0.847	0.250	0.076	0.019	0.013	0.008
2004	Toyota Camry	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2004	Toyota Camry	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2004	Toyota Camry	Yes	733	0.890	0.333	0.124	0.040	0.031	0.020
2004	Toyota Camry	Yes	502	0.803	0.190	0.048	0.009	0.006	0.003
2004	Toyota Camry	Yes	454	0.775	0.159	0.036	0.006	0.004	0.002
2016	Toyota Prius	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2016	Toyota Prius	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2016	Toyota Prius	Yes	999	0.938	0.473	0.230	0.108	0.089	0.068
2016	Toyota Prius	Yes	793	0.904	0.367	0.147	0.053	0.041	0.028
2016	Toyota Prius	Yes	740	0.892	0.337	0.127	0.042	0.032	0.021
2016	Toyota Prius	Yes	659	0.869	0.288	0.097	0.027	0.020	0.013
2016	Toyota Prius	Yes	495	0.800	0.185	0.046	0.008	0.006	0.003
2016	Toyota Prius	No	449	0.771	0.156	0.035	0.005	0.003	0.002
2016	Toyota Prius	No	366	0.706	0.105	0.018	0.002	0.001	0.000
2016	Toyota Prius	Yes	350	0.690	0.096	0.016	0.002	0.001	0.000
2016	Toyota Prius	No	335	0.675	0.087	0.013	0.001	0.001	0.000
2016	Toyota Prius	No	313	0.650	0.075	0.011	0.001	0.000	0.000
2021	VW Arteon	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2021	VW Arteon	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068

2021	VW Arteon	Yes	913	0.926	0.431	0.195	0.083	0.067	0.049
2021	VW Arteon	Yes	835	0.913	0.390	0.164	0.063	0.050	0.035
2021	VW Arteon	No	833	0.912	0.389	0.163	0.062	0.049	0.035
2021	VW Arteon	Yes	775	0.900	0.357	0.140	0.049	0.038	0.026
2021	VW Arteon	Yes	708	0.884	0.318	0.115	0.036	0.027	0.017
2021	VW Arteon	No	526	0.816	0.205	0.054	0.011	0.007	0.004
2021	VW Arteon	Yes	505	0.805	0.191	0.048	0.009	0.006	0.003
2021	VW Arteon	No	484	0.793	0.178	0.043	0.008	0.005	0.003
2021	VW Arteon	Yes	467	0.783	0.167	0.039	0.006	0.004	0.002
2021	VW Arteon	Yes	414	0.746	0.134	0.027	0.004	0.002	0.001
2021	VW Arteon	Yes	411	0.744	0.132	0.026	0.003	0.002	0.001
2021	VW Arteon	Yes	394	0.730	0.122	0.023	0.003	0.002	0.001
2021	VW Arteon	Yes	338	0.678	0.089	0.014	0.001	0.001	0.000
2006	VW Passat	No	1302	0.964	0.597	0.352	0.212	0.186	0.156
2006	VW Passat	No	836	0.913	0.391	0.164	0.063	0.050	0.035
2006	VW Passat	Yes	734	0.891	0.333	0.124	0.041	0.031	0.020
2006	VW Passat	Yes	565	0.834	0.230	0.066	0.015	0.010	0.006
2006	VW Passat	Yes	378	0.717	0.112	0.020	0.002	0.001	0.001
Average			**781.41**	**0.864**	**0.339**	**0.152**	**0.073**	**0.062**	**0.049**

Table 156: Regulatory Option #3: Test Area=Hood Top % Change in Probability of Fatal and Non-Fatal Injury for Passenger Cars

Injury Severity	Baseline	Treated	Percentage Change
MAIS 1+F	0.867	0.864	0.4%
MAIS 2+F	0.363	0.339	6.6%
MAIS 3+F	0.181	0.152	16.1%
MAIS 4+F	0.104	0.073	29.8%
MAIS 5+F	0.092	0.062	33.2%
Fatalities	0.080	0.049	38.3%

Table 157: Regulatory Option #3: Test Area=Hood Top Probability of Fatal and Non-Fatal Injuries for LTV

Year	Vehicle	Within HIC1000	Treated HIC	MAIS 1+F	MAIS 2+F	MAIS 3+F	MAIS 4+F	MAIS 5+F	Fatal
2010	Acura MDX	No	1696	0.980	0.712	0.491	0.358	0.329	0.296
2010	Acura MDX	No	1283	0.963	0.590	0.345	0.205	0.179	0.150
2010	Acura MDX	No	1100	0.949	0.519	0.272	0.141	0.119	0.094
2010	Acura MDX	No	785	0.903	0.362	0.144	0.051	0.040	0.027
2010	Acura MDX	Yes	550	0.827	0.220	0.061	0.013	0.009	0.005
2005	Chevrolet Silverado	No	1274	0.962	0.587	0.341	0.202	0.176	0.147
2005	Chevrolet Silverado	No	1133	0.952	0.532	0.285	0.152	0.129	0.103
2005	Chevrolet Silverado	No	1048	0.943	0.496	0.251	0.124	0.103	0.080
2005	Chevrolet Silverado	Yes	929	0.928	0.439	0.202	0.088	0.071	0.053
2005	Chevrolet Silverado	Yes	889	0.922	0.419	0.185	0.077	0.061	0.045
2005	Chevrolet Silverado	Yes	864	0.918	0.406	0.175	0.070	0.056	0.040
2005	Chevrolet Silverado	Yes	833	0.912	0.389	0.163	0.062	0.049	0.035
2005	Chevrolet Silverado	Yes	740	0.892	0.337	0.127	0.042	0.032	0.021
2016	Chevrolet Tahoe	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2016	Chevrolet Tahoe	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2016	Chevrolet Tahoe	No	1502	0.974	0.661	0.426	0.287	0.258	0.225

2016	Chevrolet Tahoe	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2016	Chevrolet Tahoe	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2016	Chevrolet Tahoe	Yes	979	0.935	0.464	0.222	0.102	0.084	0.064
2016	Chevrolet Tahoe	Yes	764	0.898	0.351	0.136	0.047	0.036	0.024
2016	Chevrolet Tahoe	No	615	0.854	0.261	0.082	0.021	0.015	0.009
2016	Chevrolet Tahoe	Yes	611	0.853	0.259	0.081	0.020	0.015	0.009
2016	Chevrolet Tahoe	Yes	506	0.806	0.192	0.049	0.009	0.006	0.003
2016	Chevrolet Tahoe	Yes	398	0.734	0.124	0.024	0.003	0.002	0.001
1999	Dodge Dakota	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
1999	Dodge Dakota	No	1658	0.979	0.702	0.479	0.345	0.315	0.282
1999	Dodge Dakota	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
1999	Dodge Dakota	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
1999	Dodge Dakota	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
1999	Dodge Dakota	Yes	859	0.917	0.403	0.173	0.069	0.055	0.039
1999	Dodge Dakota	Yes	763	0.898	0.350	0.135	0.047	0.036	0.024
1999	Dodge Dakota	Yes	448	0.771	0.155	0.034	0.005	0.003	0.002
2006	Dodge Durango	No	1685	0.980	0.709	0.488	0.354	0.325	0.292
2006	Dodge Durango	No	1032	0.942	0.489	0.244	0.119	0.099	0.076
2006	Dodge Durango	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2006	Dodge Durango	Yes	981	0.935	0.465	0.223	0.103	0.085	0.064
2006	Dodge Durango	Yes	769	0.899	0.353	0.138	0.048	0.037	0.025
2006	Dodge Durango	Yes	729	0.889	0.330	0.122	0.040	0.030	0.020
2006	Dodge Durango	Yes	476	0.788	0.173	0.041	0.007	0.005	0.002
2006	Dodge Durango	Yes	343	0.683	0.092	0.015	0.001	0.001	0.000
2003	Dodge Ram	No	1321	0.965	0.604	0.360	0.219	0.193	0.162
2003	Dodge Ram	No	1193	0.956	0.557	0.309	0.173	0.149	0.121
2003	Dodge Ram	Yes	626	0.858	0.268	0.086	0.022	0.016	0.010
2003	Dodge Ram	Yes	614	0.854	0.260	0.081	0.021	0.015	0.009
2003	Dodge Ram	Yes	555	0.830	0.223	0.063	0.014	0.010	0.005
2003	Ford E350	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Ford E350	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Ford E350	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Ford E350	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Ford E350	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068

2003	Ford E350	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Ford E350	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Ford E350	Yes	868	0.919	0.408	0.177	0.071	0.057	0.041
2016	Ford Edge	No	1297	0.964	0.595	0.350	0.211	0.184	0.154
2016	Ford Edge	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2016	Ford Edge	Yes	822	0.910	0.383	0.158	0.060	0.047	0.033
2016	Ford Edge	No	805	0.907	0.374	0.152	0.056	0.043	0.030
2016	Ford Edge	No	792	0.904	0.366	0.147	0.053	0.041	0.028
2016	Ford Edge	Yes	740	0.892	0.337	0.127	0.042	0.032	0.021
2016	Ford Edge	Yes	543	0.824	0.216	0.059	0.013	0.009	0.005
2016	Ford Edge	Yes	524	0.815	0.204	0.054	0.011	0.007	0.004
2016	Ford Edge	Yes	467	0.783	0.167	0.039	0.006	0.004	0.002
2001	Ford Escape	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2001	Ford Escape	No	1131	0.951	0.532	0.284	0.151	0.129	0.103
2001	Ford Escape	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2001	Ford Escape	Yes	948	0.931	0.449	0.210	0.093	0.076	0.057
2001	Ford Escape	Yes	839	0.913	0.392	0.165	0.064	0.050	0.036
2001	Ford Escape	Yes	708	0.884	0.318	0.115	0.036	0.027	0.017
2001	Ford Escape	Yes	406	0.740	0.129	0.025	0.003	0.002	0.001
2015	Ford F-150	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2015	Ford F-150	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2015	Ford F-150	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2015	Ford F-150	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2015	Ford F-150	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2015	Ford F-150	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2015	Ford F-150	No	999	0.938	0.473	0.230	0.108	0.089	0.068
2015	Ford F-150	Yes	575	0.838	0.236	0.069	0.016	0.011	0.006
2011	Ford Ranger (Aluminum)	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2011	Ford Ranger (Aluminum)	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2011	Ford Ranger (Aluminum)	Yes	351	0.691	0.096	0.016	0.002	0.001	0.000
2011	Ford Ranger (Steel)	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2011	Ford Ranger (Steel)	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2011	Ford Ranger (Steel)	Yes	751	0.895	0.343	0.131	0.044	0.034	0.023
2004	GMC Savana	Yes	984	0.936	0.466	0.224	0.104	0.085	0.065
2004	GMC Savana	Yes	585	0.843	0.242	0.072	0.017	0.012	0.007

2004	GMC Savana	Yes	582	0.841	0.240	0.071	0.017	0.012	0.007
2004	GMC Savana	Yes	524	0.815	0.204	0.054	0.011	0.007	0.004
2005	Honda CRV	No	1197	0.957	0.558	0.311	0.174	0.150	0.122
2005	Honda CRV	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2005	Honda CRV	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2005	Honda CRV	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2005	Honda CRV	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2005	Honda CRV	Yes	938	0.930	0.444	0.205	0.090	0.073	0.054
2005	Honda CRV	Yes	749	0.894	0.342	0.130	0.044	0.033	0.022
2005	Honda CRV	Yes	671	0.873	0.296	0.101	0.029	0.022	0.014
2011	Honda Odyssey	No	1358	0.967	0.616	0.374	0.233	0.206	0.175
2011	Honda Odyssey	No	1302	0.964	0.597	0.352	0.212	0.186	0.156
2011	Honda Odyssey	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2011	Honda Odyssey	Yes	731	0.890	0.331	0.123	0.040	0.030	0.020
2003	Hummer H2	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2003	Hummer H2	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Hummer H2	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Hummer H2	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Hummer H2	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Hummer H2	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Hummer H2	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Hummer H2	Yes	909	0.925	0.429	0.194	0.082	0.066	0.048
2010	Hyundai Tucson	No	1484	0.973	0.655	0.420	0.280	0.251	0.219
2010	Hyundai Tucson	No	1036	0.942	0.490	0.246	0.120	0.100	0.077
2010	Hyundai Tucson	No	638	0.862	0.275	0.090	0.024	0.018	0.011
2010	Hyundai Tucson	No	461	0.779	0.163	0.037	0.006	0.004	0.002
2011	Jeep Grand Cherokee	No	979	0.935	0.464	0.222	0.102	0.084	0.064
2011	Jeep Grand Cherokee	No	877	0.920	0.413	0.181	0.074	0.059	0.042
2011	Jeep Grand Cherokee	No	651	0.867	0.283	0.094	0.026	0.019	0.012
2011	Jeep Grand Cherokee	Yes	491	0.797	0.182	0.045	0.008	0.005	0.003
2002	Jeep Wrangler	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2002	Jeep Wrangler	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2002	Jeep Wrangler	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2002	Jeep Wrangler	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2002	Jeep Wrangler	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2002	Jeep Wrangler	Yes	553	0.829	0.222	0.062	0.014	0.009	0.005

2002	Jeep Wrangler	Yes	456	0.776	0.160	0.036	0.006	0.004	0.002
2002	Jeep Wrangler	Yes	379	0.717	0.113	0.020	0.002	0.001	0.001
2016	Nissan Rogue	No	1096	0.948	0.517	0.270	0.140	0.118	0.093
2016	Nissan Rogue	No	1074	0.946	0.507	0.261	0.132	0.111	0.087
2016	Nissan Rogue	No	715	0.886	0.322	0.117	0.037	0.028	0.018
2016	Nissan Rogue	Yes	690	0.879	0.307	0.108	0.033	0.024	0.015
2016	Nissan Rogue	Yes	566	0.835	0.230	0.066	0.015	0.010	0.006
2016	Nissan Rogue	No	563	0.833	0.228	0.065	0.015	0.010	0.006
2016	Nissan Rogue	Yes	532	0.819	0.209	0.056	0.012	0.008	0.004
2016	Nissan Rogue	Yes	423	0.753	0.140	0.029	0.004	0.003	0.001
2020	Subaru Outback	No	1077	0.946	0.509	0.262	0.133	0.112	0.088
2020	Subaru Outback	No	1055	0.944	0.499	0.254	0.126	0.106	0.082
2020	Subaru Outback	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2020	Subaru Outback	No	992	0.937	0.470	0.227	0.106	0.087	0.066
2020	Subaru Outback	No	758	0.896	0.347	0.133	0.045	0.035	0.023
2020	Subaru Outback	Yes	741	0.893	0.338	0.127	0.042	0.032	0.021
2020	Subaru Outback	Yes	719	0.887	0.324	0.119	0.038	0.028	0.019
2020	Subaru Outback	Yes	612	0.853	0.259	0.081	0.021	0.015	0.009
2020	Subaru Outback	Yes	545	0.825	0.217	0.060	0.013	0.009	0.005
2020	Subaru Outback	Yes	441	0.766	0.151	0.033	0.005	0.003	0.002
2020	Subaru Outback	Yes	418	0.749	0.136	0.028	0.004	0.002	0.001
2020	Subaru Outback	Yes	329	0.669	0.084	0.013	0.001	0.001	0.000
2020	Subaru Outback	Yes	305	0.641	0.071	0.010	0.001	0.000	0.000
2003	Toyota 4-Runner	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2003	Toyota 4-Runner	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2003	Toyota 4-Runner	No	1344	0.966	0.611	0.368	0.228	0.201	0.170
2003	Toyota 4-Runner	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2003	Toyota 4-Runner	Yes	838	0.913	0.392	0.165	0.064	0.050	0.035
2003	Toyota 4-Runner	Yes	732	0.890	0.332	0.124	0.040	0.031	0.020
2003	Toyota 4-Runner	Yes	580	0.841	0.239	0.071	0.017	0.012	0.007
2003	Toyota 4-Runner	Yes	356	0.696	0.099	0.017	0.002	0.001	0.000
2004	Toyota Sienna	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2016	Toyota Sienna	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2016	Toyota Sienna	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068

2016	Toyota Sienna	Yes	1000	0.938	0.474	0.231	0.109	0.090	0.068
2016	Toyota Sienna	Yes	909	0.925	0.429	0.194	0.082	0.066	0.048
2016	Toyota Sienna	Yes	839	0.913	0.392	0.165	0.064	0.050	0.036
2016	Toyota Sienna	Yes	705	0.883	0.316	0.113	0.035	0.026	0.017
2016	Toyota Sienna	Yes	655	0.868	0.286	0.095	0.027	0.020	0.012
2004	Toyota Sienna	Yes	598	0.848	0.250	0.076	0.019	0.013	0.008
2016	Toyota Sienna	Yes	596	0.847	0.249	0.076	0.018	0.013	0.008
2004	Toyota Sienna	Yes	518	0.812	0.200	0.052	0.010	0.007	0.004
2004	Toyota Sienna	Yes	403	0.738	0.127	0.025	0.003	0.002	0.001
2004	Toyota Sienna	Yes	353	0.693	0.098	0.016	0.002	0.001	0.000
2006	Toyota Tacoma	No	1700	0.980	0.712	0.492	0.360	0.330	0.298
2006	Toyota Tacoma	No	1443	0.971	0.643	0.405	0.265	0.236	0.204
2006	Toyota Tacoma	No	1385	0.968	0.625	0.384	0.243	0.215	0.184
2006	Toyota Tacoma	No	947	0.931	0.448	0.209	0.093	0.076	0.056
2006	Toyota Tacoma	No	889	0.922	0.419	0.185	0.077	0.061	0.045
2006	Toyota Tacoma	Yes	513	0.809	0.197	0.051	0.010	0.007	0.004
2006	Toyota Tacoma	Yes	415	0.747	0.135	0.027	0.004	0.002	0.001
2006	Toyota Tacoma	Yes	309	0.645	0.073	0.010	0.001	0.000	0.000
Average			**903.65**	**0.896**	**0.403**	**0.196**	**0.101**	**0.086**	**0.069**

Table 158: Regulatory Option #3: Test Area=Hood Top % Change in Probability of Fatal and Non-Fatal Injury for LTV

Injury Severity	Baseline	Treated	Percentage Change
MAIS 1+F	0.904	0.896	0.9%
MAIS 2+F	0.456	0.403	11.6%
MAIS 3+F	0.260	0.196	24.6%
MAIS 4+F	0.169	0.101	40.4%
MAIS 5+F	0.153	0.086	44.0%
Fatalities	0.137	0.069	49.1%

12.8. Appendix H: Target Population

Table 159: Target Population: Annual Fatalities and Non-Fatal Injuries in Passenger Cars

Injury Severity	Year				
	2016	2017	2018	2019	2020
MAIS 0	10,024	8,455	7,875	8,473	6,152
MAIS 1	30,307	23,769	24,898	26,204	18,788
MAIS 2	5,817	4,471	4,818	4,937	3,724
MAIS 3	2,248	1,713	1,888	1,885	1,476
MAIS 4	374	285	323	311	253
MAIS 5	93	71	81	78	63
Fatality	3,224	3,182	3,368	3,220	2,407

Table 160: Target Population: Annual Fatalities and Non-Fatal Injuries in LTVs

Injury Severity	Year				
	2016	2017	2018	2019	2020
MAIS 0	6,994	5,828	6,709	5,570	11,451
MAIS 1	23,363	19,351	20,262	20,017	15,456
MAIS 2	4,380	3,725	3,764	3,882	3,092
MAIS 3	1,651	1,440	1,420	1,501	1,267
MAIS 4	265	239	231	248	225
MAIS 5	66	60	58	62	56
Fatality	3,263	3,272	3,364	3,439	2,388

Table 161: Target Population: Total Annual Fatalities and Non-Fatal Injuries

Injury Severity	Year				
	2016	2017	2018	2019	2020
MAIS 0	17,018	14,283	14,585	14,043	17,603
MAIS 1	53,670	43,120	45,160	46,221	34,244
MAIS 2	10,197	8,197	8,582	8,818	6,816
MAIS 3	3,899	3,153	3,307	3,386	2,743
MAIS 4	639	524	553	559	478
MAIS 5	160	131	138	140	119
Fatality	6,487	6,455	6,732	6,659	4,795

Table 162: Target Population: Fatalities and Non-Fatal Injuries Annually Relative to Annual Average

Injury Severity	Year				
	2016	2017	2018	2019	2020
MAIS 0	110%	92%	94%	91%	114%
MAIS 1	121%	97%	102%	104%	77%
MAIS 2	120%	96%	101%	103%	80%
MAIS 3	118%	96%	100%	103%	83%
MAIS 4	116%	95%	100%	102%	87%
MAIS 5	116%	95%	100%	102%	87%
Fatality	104%	104%	108%	107%	77%