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16. Abstract

This report presents and exercises a methodology to estimate the effectiveness and potential safety benefits of production pedestrian crash avoidance/mitigation systems. The analysis focuses on light vehicles moving forward and striking a pedestrian in the first event of a crash with no attempted avoidance maneuver in two priority scenarios: (1) vehicle going straight and pedestrian crossing the roadway, and (2) vehicle going straight and pedestrian in or adjacent to the roadway, stationary or moving with or against traffic. System effectiveness is estimated for crash avoidance and crash severity mitigation. Safety benefits are projected in terms of annual reductions in the number of police-reported vehicle-pedestrian crashes, fatal vehicle-pedestrian crashes, and injured pedestrians at Maximum Abbreviated Injury Scale 2-6 and 3-6 levels. The methodology relies on target baseline crashes obtained from the 2011 and 2012 General Estimates System and Fatality Analysis Reporting Systems crash databases, system performance data from characterization track tests, and basic kinematic computer simulation of vehicle-pedestrian conflicts.

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LIST OF ACRONYMS

AEB	automatic emergency braking
AFM	away from motor
AFV	away from vehicle
AIS	Abbreviated Injury Scale
DBA	dynamic brake assist
DSRC	dedicated short-range communications
EURO NCAP	European New Car Assessment Program
FARS	Fatality Analysis Reporting System
FOV	field of view
GES	General Estimates System
GIDAS	German In-Depth-Accident-Study
ISU	injured, severity unknown
ITARDA	Institute for Traffic Accident Research and Data Analysis
MAIS	Maximum Abbreviated Injury Scale
NASS	National Automotive Sampling System
NHTSA	National Highway Traffic Safety Administration
OEM	original equipment manufacturer
PCAM	pedestrian crash avoidance/mitigation
PCS	pre-collision system
SCI	special crash investigation
SV	subject vehicle
TM	towards motor
TRC	Transportation Research Center
TTC	time-to-collision
TV	towards vehicle
V2P	vehicle-to-pedestrian
V2V	vehicle-to-vehicle
VRTC	Vehicle Research and Test Center
VRU	vulnerable road user

EXECUTIVE SUMMARY

The Volpe National Transportation Systems Center (Volpe), in support of the National Highway Traffic Safety Administration (NHTSA), developed and exercised a methodology to estimate the potential safety benefits for production pedestrian crash avoidance/mitigation (PCAM) systems. PCAM systems are vehicle-based, forward-looking pedestrian detection systems that alert drivers of potential vehicle-pedestrian crashes and/or apply automatic emergency braking (AEB) to prevent potential vehicle-pedestrian crashes. This report focuses on crashes that involved light-vehicles (i.e., passenger cars, vans and minivans, sport utility vehicles, and light pickup trucks with gross vehicle weight rating under 10,000 pounds) moving forward, striking a pedestrian in the first event of the crash, and not attempting any avoidance action.

As the number of all fatalities on trafficways continues to decrease, the proportion of pedestrian fatalities is on the rise. This report describes and exercises a methodology to estimate the potential safety benefits for PCAM systems in terms of crash avoidance and crash mitigation measures, and three variations of PCAM system logic (between driver and system interaction) as described in Table ES1.[1,2]

Table ES1: PCAM System Effectiveness Measures and System Logic Implementation Techniques

PCAM System Effectiveness Measure		System Logic Implemented for both Crash Avoidance and Crash Mitigation	
Crash Avoidance	Ability to avoid a vehicle-pedestrian crash through driver warning and/or AEB (annual crashes reduced)	**AEB Only**	**AEB** intervention only, no warning.
Crash Mitigation	Ability to mitigate pedestrian injury from a reduction in impact speed through driver warning and/or AEB if a vehicle-pedestrian crash is unavoidable (pedestrian injuries reduced at Maximum Abbreviated Injury Scale (MAIS) 2-6 (2^+) and 3-6 (3^+) levels)	**FIRST Braking**	**FIRST** braking response applied after warning, driver or AEB.
		BEST Braking	**BEST** active braking response applied between driver and AEB.[3]

A query of the 2011 and 2012 General Estimates Systems (GES) and Fatality Analysis Reporting (FARS) crash databases shows that light-vehicles strike a pedestrian in the first event on average 62,917 times for crashes of all severities and 3,337 times for fatal vehicle-pedestrian crashes.[4]

[1] These logic parameters were introduced at the system level. Therefore all three system logic methods apply to both system effectiveness measures (crash avoidance and crash mitigation).

[2] Every PCAM system uses unique warning and suppression algorithms. The selected logic models were choses as they represent very common system logic models.

[3] If only one braking response is active, the active braking response is used. If at any time both braking responses are active (driver and AEB), then the highest braking level is used to respond from the initial time both responses were active.

[4] First event of the crash was chosen as secondary events may not allow for intervention (e.g., rollover).

These crashes accounted for 13,058 injured pedestrians at the Maximum Abbreviated Injury Scale (MAIS) 2^+ level and 6,770 at the MAIS 3^+ level. The focus of this report is on two prominent vehicle-pedestrian pre-crash scenarios, these scenarios and crash statistics are shown in Table ES2.

Table ES2: Prominent Two Vehicle-Pedestrian Scenarios and Annual Average (2011-2012) Crash Statistics for a Light-Vehicle Striking a Pedestrian in the First Event

Scenario^	Scenario Description	GES Crashes	FARS Crashes	MAIS 2+ Pedestrians	MAIS 3+ Pedestrians
S1	Vehicle going straight and pedestrian crossing the roadway	23,558	2,029	6,063	3,553
S4	Vehicle going straight and pedestrian in or adjacent to the roadway, stationary or moving with or against traffic	9,340	977	2,658	1,626
Percent Total of Vehicle-Pedestrian Crashes*		**52%**	**90%**	**67%**	**76%**

^Name convention is used from identifying the most common vehicle-pedestrian pre-crash scenarios. Of the identified pre-crash scenarios, system effectiveness and benefits were obtained for only these two pre-crash scenarios.
*Light-vehicle striking a pedestrian in the first event of crash

The two pre-crash scenarios listed above (S1 and S4) account for approximately 33,000 (52%) of vehicle-pedestrian crashes and 3,000 (90%) of fatal vehicle-pedestrian crashes with a light-vehicle striking a pedestrian in the first event. Furthermore, these crashes account for 67 percent of MAIS 2^+ and 76 percent of MAIS 3^+ injured pedestrians. However, PCAM systems may only address a subset of these crashes.

This report focuses on PCAM-addressable crashes, which involve a light-vehicle moving forward and striking a pedestrian with the front of the vehicle in the first event of a crash, with the driver attempting no avoidance maneuver.[5] Based on these criteria, these two pre-crash scenarios account for 17 percent (10,431 S1 and S4) of the 62,917 vehicle-pedestrian crashes and 60 percent (2,016 S1 and S4) of the 3,337 fatal vehicle-pedestrian crashes. These crashes with further constraints account for only 30 percent (3,889 S1 and S4) of the 13,058 MAIS 2^+ injured pedestrians and only 40 percent (2,739 S1 and S4) of the 6,770 MAIS 3^+ injured pedestrians.[6]

Estimates of PCAM crash avoidance and mitigation effectiveness are derived from computer simulations using historical crash information and performance data from system characterization tests of three production PCAM systems. The conditions and results of system performance testing were then correlated to historical crash data to accurately represent the intervention of PCAM systems in crash cases of the two target pre-crash scenarios. Table ES3 shows estimates of crash avoidance effectiveness and safety benefits for PCAM systems. These results represent the best performing vehicle for each scenario with only AEB as the active countermeasure (i.e., no warning). Observed results show that warnings were issued almost simultaneously with AEB activation (< 1 sec prior) and that drivers could provide marginal

[5] Impaired drivers are considered. Impaired drivers can benefit from AEB; it is assumed they will not respond to the warning, but AEB does not require driver input.
[6] See Figure ES1 for a breakdown of statistics.

improvements with earlier or harder braking given the minimal warning time (i.e., no difference in benefits when a warning was issued and driver provided input).

Table ES3: Potential Crash Avoidance Effectiveness and Safety Benefits for PCAM Systems, AEB Only[7]

Scenario	Crash Avoidance Effectiveness[8]	GES Crashes Reduced	FARS Crashes Reduced	Costs Reduced ($M)[9]	Equivalent Lives Saved[10]
S1	76.4%	4,324	675	$ 6,857	750
S4	85.9%	663	135	$ 1,380	151
Total System	**77.6%**	**4,987**	**810**	**$ 8,237**	**901**

In addition to crash reduction, estimates of crash mitigation effectiveness were determined using pedestrian injury probability curves and impact speed results from computer simulations. Crash mitigation effectiveness accounts for the reduction in injured pedestrians from avoided crashes and for reduced injury levels of injured pedestrians from non-avoided crashes due to lower impact speeds as a result of driver or PCAM intervention. Table ES4 lists estimates of crash mitigation effectiveness (which includes crash avoidance) and resulting safety benefits for PCAM systems, again for the best performing vehicle in each scenario with AEB being the only active countermeasure (marginal improvements from drivers with minimal time between warning and AEB activation).

Table ES4: Potential Crash Mitigation Effectiveness and Safety Benefits for PCAM System, AEB Only

	Scenario	Harm Measure	Crash Mitigation Effectiveness[8,11]	Reduced Injured Pedestrians	Costs Reduced ($M)	Equivalent Lives Saved
AEB Only	S1	MAIS 2+	91.0%	1,620	$ 8,046	880
		MAIS 3+	95.6%	1,154	$ 8,206	897
	S4	MAIS 2+	94.5%	329	$ 1,594	174
		MAIS 3+	96.5%	236	$ 1,604	175
	Total System	MAIS 2+	91.6%	1,948	$ 9,640	1,054
		MAIS 3+	95.8%	1,391	$ 9,810	1,073

The analysis in this report estimates that the crash avoidance effectiveness of PCAM systems, based on the performance data of three production systems can reduce up to 5,000 annual vehicle-pedestrian crashes and 810 fatal vehicle-pedestrian crashes. These crashes account for 8 percent of crash population where light-vehicles strike a pedestrian in the first event and 24 percent of same crash types where fatalities were involved. If a crash is unavoidable, PCAM

[7] These estimates are based on the highest system effectiveness value obtained from simulation results, based on the three OEMs tested.

[8] Effectiveness estimates are derived from the sub-set of crashes that could be correlated to the specific testing conditions and used in crash reconstruction. A total of 6,428 crashes and 1,053 fatal crashes met this criteria, see Figure ES1.

[9] Comprehensive costs estimate includes lost productivity, medical costs, legal and court costs, emergency service costs, insurance administration costs, travel delay, property damage, and workplace losses.

[10] Equivalent lives saved is a measure that correlates comprehensive costs reduced to fatalities.

[11] Effectiveness estimates account for injuries reduced from crash mitigation.

systems could reduce the resulting number of injured pedestrians through impact speed reduction. Overall, these systems have the capability to annually reduce up to 1,950 inured pedestrians at the MAIS 2^+ levels and 1,400 injured pedestrians at the MAIS 3^+ level. These estimates account for 15 percent of the 13,058 pedestrians that are injured at the MAIS 2^+ levels when a light-vehicle strikes a pedestrian in the first event and 21 percent of the 6,770 MAIS 3^+ pedestrian under the same crash conditions. Figure ES1 displays a detailed breakdown of crash statistics and how they are incorporated into the safety benefits and system effectiveness estimates.

The methodology presented in this report to estimate the safety benefits for PCAM safety systems relied on the availability and accuracy of real-world data. However, with the current state of crash data and collection methods, many data gaps exist and create a need for additional information. Therefore, this methodology supplemented historical crash data with objective testing of production vehicle systems and previous literature/research. This information was input into a simulation to compare historical vehicle-pedestrian crashes with synthetic crashes, superimposing PCAM system performance on these historical crashes. Using this method and the limited data available, safety benefits estimates are presented at a high level.

Further research and information to supplement the existing data will strengthen and refine the safety benefits derived in this report. Objective testing was limited to only three production vehicle systems under six specific conditions (e.g., atmospheric and lighting). The performance of these three systems was not indicative of other vehicle systems using other technology nor other environmental conditions. Furthermore, as the technology within PCAM systems continues to improve over time, these three systems may not be representative of future technology. The limited objective testing conditions may not take advantage of the full operational capabilities of these PCAM systems. Due to the unknown performance of PCAM systems in other scenarios and other environmental conditions, it could not be assumed that PCAM systems will have any safety benefit. Therefore a conservative approach was taken and crashes that could not be directly correlated to specific test conditions received no safety benefit.[12] Additionally, limited information on driver-vehicle interaction of these PCAM systems required this report to generalize the interaction with three simplified system logic approaches.

This report provides a foundation for a benefits method and exercised this method to estimate the potential safety benefits of available PCAM systems. As technology continues to improve, deploy, and as more data becomes available (e.g., crash data, human factors data,[13] system performance data), the method applied and results can be updated. Further, the method described can be applied to other vehicle technologies, as this method is technologically independent and defines all the data parameters necessary to estimate benefits. This paper can aid industry

[12] The system performance estimates for the test PCAM systems were specific to explicit testing conditions and may not be representative of real-world effectiveness (positive or negative). Compounding circumstances of technology, environment, and other extenuating circumstances could not be accurately considered at the time of this report. Further research on the effect of these factors would provide refined performance estimates.

[13] Human factor based testing includes driver performance in vehicle-pedestrian crashes (i.e., reaction time and braking level) and pedestrian performance (e.g., movement behavior while crossing the road or walking along the road, reactions to approaching vehicles).

professionals in future research and development of advanced vehicle technologies, as the report describes the type of data needed and how specific information is applied.

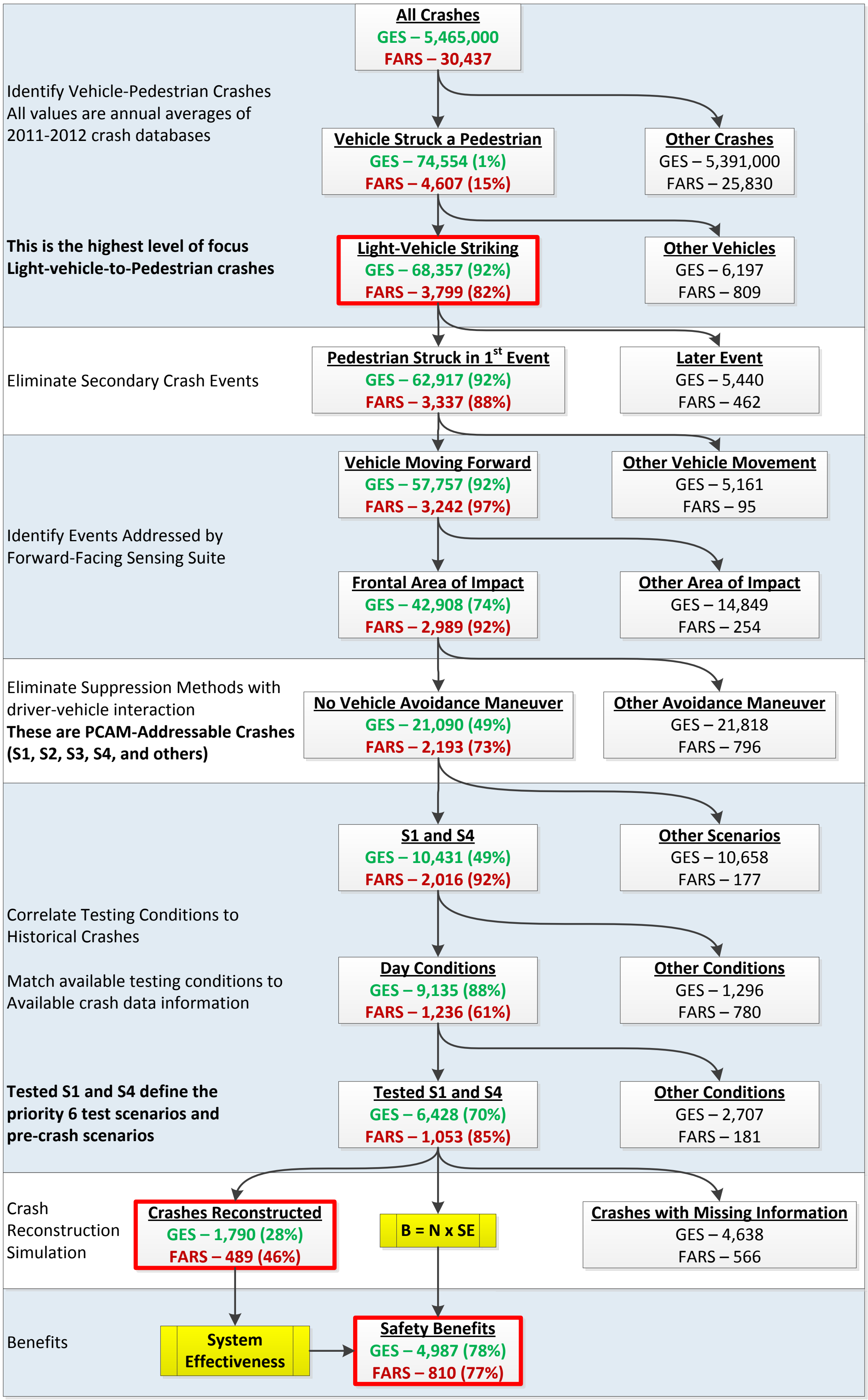

Figure ES1: Detailed Breakdown of Crashes Statistics and Relationship to Safety Benefits

1 INTRODUCTION

This report describes and applies a methodology to estimate the potential safety benefits for pedestrian crash avoidance/mitigation (PCAM) systems. PCAM systems are light vehicle-based forward-facing sensor systems that detect a pedestrian and warn the driver and/or apply automatic emergency braking (AEB) to avoid an imminent vehicle-pedestrian crash or reduce the impact speed.[14] PCAM systems use radar, camera, and/or laser sensing technology to detect pedestrians in the vehicle's travel path. Safety benefits are expressed as reductions in annual vehicle-pedestrian crashes of all severities, fatal vehicle-pedestrian crashes, and pedestrian injuries.

1.1 About this Report

This report provides a foundation for a benefits method and exercised this method to estimate the potential safety benefits of available PCAM systems. As technology continues to improve, deploy, and as more data becomes available (e.g., crash data, human factors data, system performance data), the method applied and results can be updated. Further, the method described can be applied to other vehicle technologies, as this method is technologically independent and defines all the data parameters necessary to estimate benefits. This paper can aid industry professionals in future research and development of advanced vehicle technologies, as the report describes the type of data needed and how specific information is applied.

1.2 Pedestrian Crash Statistics

From 2004 to 2013 there have been 373,598 police-reported fatalities on public traffic-ways according to data from the National Highway Traffic Safety Administration (NHTSA) Traffic Safety Facts [1]. NHTSA has made significant strides in reducing the frequency of total fatalities since 2004 through research programs, safety outreach campaigns, and vehicle regulation. As the frequency of traffic-way fatalities has decreased over the last 10 years, the proportion of pedestrian fatalities continues to slowly rise as seen in Figure 1. The deployment of PCAM systems could have an immediate impact in decreasing vehicle-pedestrian crashes and resulting pedestrian injuries and fatalities.

[14] Light vehicles are passenger cars, vans and minivans, sport utility vehicles, and light pickup trucks with gross vehicle weight rating under 10,000 pounds.

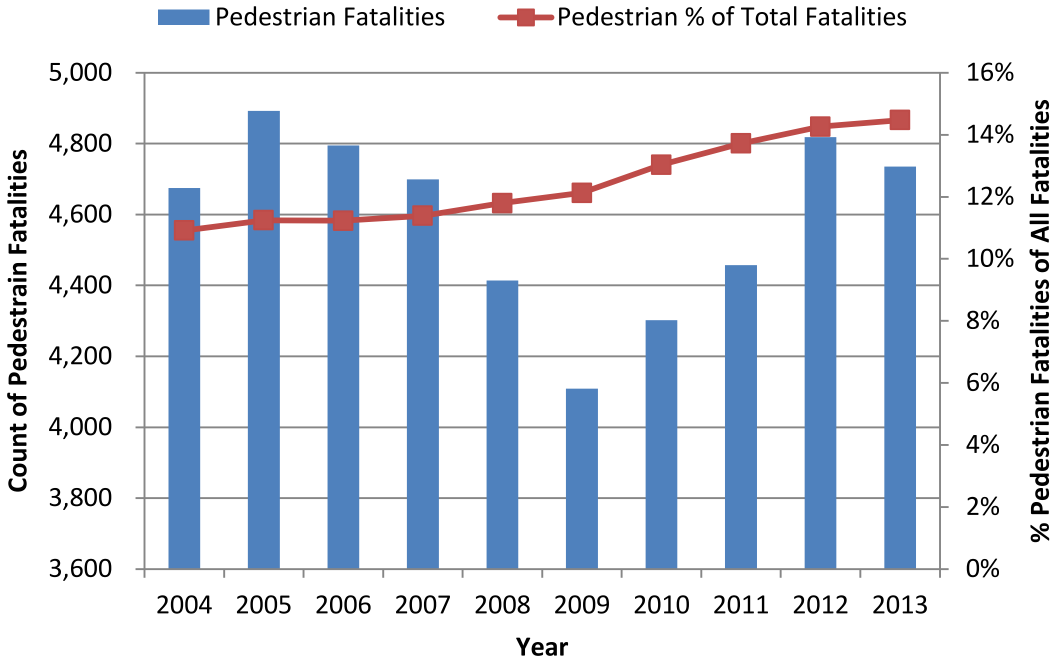

Figure 1: Annual Pedestrian Fatalities in the United States

Previous research by the Volpe National Transportation Systems Center identified and prioritized vehicle-pedestrian pre-crash scenarios and developed a methodology to estimate the potential safety benefits of PCAM applications [2].[15] Four vehicle-pedestrian pre-crash scenarios were recommended as target scenarios for PCAM systems based on the analysis of the 2005 through 2009 NHTSA's National Automotive Sampling System (NASS) General Estimates System (GES) and Fatality Analysis Reporting System (FARS) crash databases[3][4]. These four priority pre-crash scenarios are depicted in Figure 2:

S1 - Vehicle going straight and pedestrian crossing the road
S2 - Vehicle turning right and pedestrian crossing the road
S3 - Vehicle turning left and pedestrian crossing the road
S4 - Vehicle going straight and pedestrian walking alongside the road with/or against traffic.

[15] Pre-crash scenarios depict specific vehicle and pedestrian movements as well as the critical event occurring immediately prior to the crash.

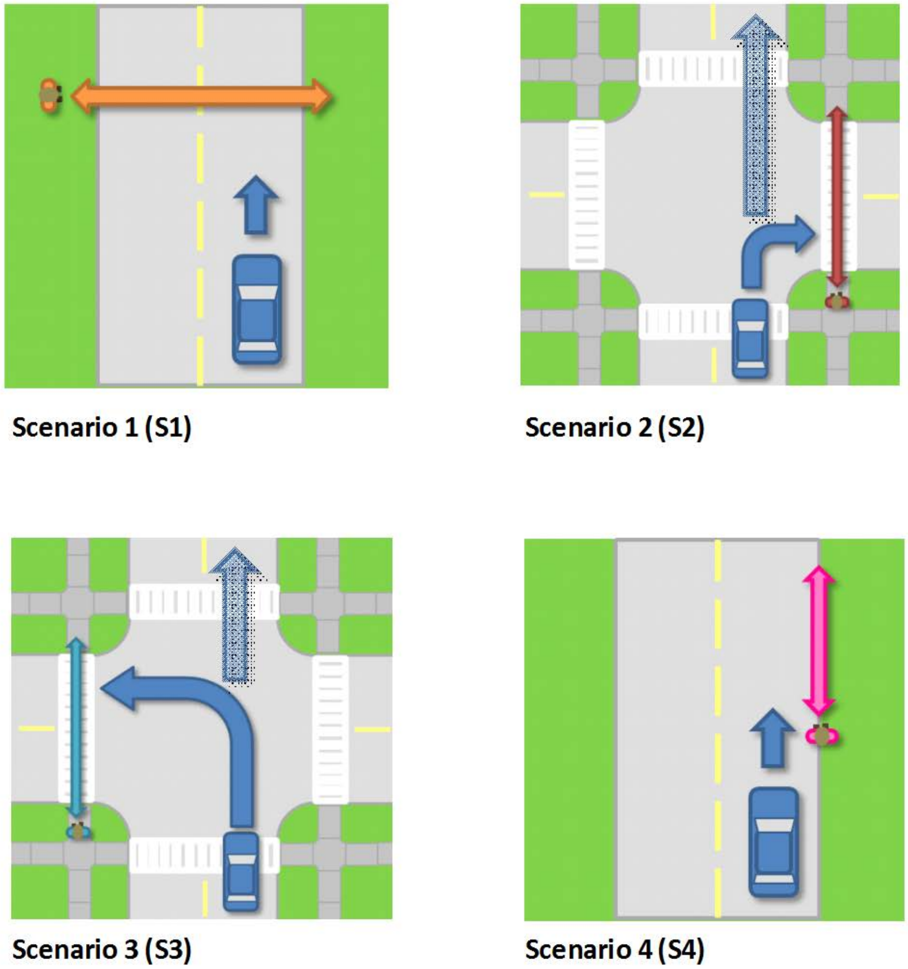

Figure 2: Recommended Scenarios for PCAM Priority Pre-Crash Scenarios

Pedestrian crash statistics were updated in a recent report that correlated pre-crash scenarios and their characteristics to vehicle-to-pedestrian (V2P) communication-based crash avoidance applications [5].[16] This research was based on the 2011 and 2012 GES and FARS databases, and defined the following five priority pre-crash scenarios:

1. Vehicle going straight and pedestrian crossing the road
2. Vehicle going straight and pedestrian in the road
3. Vehicle going straight and pedestrian adjacent to the road
4. Vehicle turning left and pedestrian crossing the road
5. Vehicle turning right and pedestrian crossing the road

The top priority vehicle-pedestrian pre-crash scenarios remained prominent from 2005 to 2012. In terms of kinematics, the second scenario "vehicle going straight and pedestrian in the road" is

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[16] V2P based safety systems use wireless communication to transfer information between vehicles and pedestrians including dedicated short-range communications (DSRC), Wi-Fi, GPS tracking via cellular networks, or others.

similar to the third scenario “vehicle going straight and pedestrian adjacent to the road”. These two scenarios have a pedestrian in the direct path of a vehicle for a longer duration. Therefore, these two pre-crash scenarios are combined into one. Thus, this report focuses on the top four pre-crash scenarios as described by the previously published PCAM research (i.e., S1, S2, S3, and S4 in Figure 2). These four pre-crash scenarios represent the most prominent vehicle-pedestrian crashes, in terms of frequency and injury.

The average annual number of all police-reported vehicle-pedestrian crashes involving a light-vehicle striking a pedestrian in the first event amounts to 62,917 crashes based on 2011 and 2012 GES statistics. Based on similar criteria in 2011 and 2012 FARS data, there are 3,337 fatal vehicle-pedestrian crashes annually. However, PCAM systems may only target a subset of these crashes. PCAM-addressable crashes involve the vehicle moving forward and striking a pedestrian with the front of the vehicle and the driver attempting no avoidance maneuver, in addition to the previous criteria (light-vehicle striking a pedestrian in the first event of the crash).[17] As a result, the average annual number of all police-reported PCAM-addressable crashes amounts to about 21,000 crashes based on GES statistics. Based on FARS data, there are about 2,200 fatal PCAM-addressable crashes annually.

Table 1 shows the four priority pre-crash scenarios as a proportion of all and fatal PCAM-addressable vehicle-pedestrian crashes as reported respectively in the 2011-2012 GES and FARS databases. These four scenarios account for 90 percent of all GES and 97 percent of all FARS PCAM-addressable vehicle-pedestrian crashes.[18]

Table 1: Breakdown of Priority PCAM-Addressable* Pre-Crash Scenarios[19]

Scenario	Vehicle Maneuver	Pedestrian Maneuver	GES Frequency		FARS Frequency	
S1	Going Straight	Crossing Roadway	7,481	35.5%	1,396	64%
S2	Turning Right	Crossing Roadway	2,264	10.7%	24	1%
S3	Turning Left	Crossing Roadway	6,200	29.4%	87	4%
S4	Going Straight	Walking along Roadway, with/against Traffic	2,950	14.0%	620	28%
Other Scenarios			2,195	10.4%	66	3%
Annual Average Total PCAM-Addressable**			**21,090**		**2,193**	

*PCAM-addressable crashes are crashes involve a light-vehicle striking a pedestrian with the front of the vehicle in the first event of a crash, with no avoidance maneuver
**Annual averages are based on 2011 and 2012 crash data

[17] These crashes were selected as a subset for PCAM systems: sensing systems face forward, are typically active for only forward moving vehicles, eliminates any potential system suppression algorithms, and reduces complications from secondary events within the crash.
[18] PCAM-addressable crashes are approximately 34 percent of all vehicle-pedestrian crashes and 66 percent of all fatal vehicle-pedestrian crashes annually.
[19] This data shows the number of pedestrians that were struck in the first event of a crash by a light vehicle, with the driver attempting no avoidance maneuver.

1.3 PCAM Systems

A technology scan was conducted to understand the functionality and operational conditions of current and near-term production PCAM systems. The dynamics of a vehicle-pedestrian crash offer several intervention or countermeasure opportunities for PCAM systems (i.e., warn driver, warn pedestrian, brake vehicle, and/or steer vehicle). The technology scan divided PCAM systems by their applicable countermeasure approach. PCAM systems utilize various forms of technology and the analysis conducted within this report is independent of technological implementation.[20]

The technology scan showed that PCAM systems provide warnings and automatic control by activating the vehicle brakes and/or steering in order to avoid a crash. Table 2 shows results from the technology scan, broken down by the PCAM system type (countermeasure profile).

Table 2: Number of PCAM Systems (Current and Near-Term) Reviewed in Technology Scan

PCAM System Type (Countermeasure Profile)	Warning Issued To		
	Driver	Pedestrian	No Warning
Warn Only	4	1	
Warn and Brake Assist	2		
Warn and Automatic Brake	3		
Brake Assist Only			1
Warn, Automatic Brake and/or Steer	2		

Since publicly-available information was used (e.g., media publications, owner's manuals, publicized testing), fully detailed system capabilities and limitations may not be available (e.g., warning suppression techniques, minimum and maximum thresholds for activation). Estimating potential safety benefits for various countermeasure profiles requires different sources of input data. Benefits estimation of PCAM warning systems requires system performance and driver response data, whereas AEB systems benefits estimation require only system performance data. Each component of the PCAM systems is subsequently described in the sections below along with the assessment of potential input data.

1.3.1 Warning System

Warnings can be provided to the driver as visual, audible, and/or haptic alerts. These systems typically alert the driver and expect the driver to properly assess the driving conflict and respond accordingly to avoid a crash. The review of five warning-only systems revealed that:

[20] The technology scan only included "the technologies used" and "the countermeasure profiles introduced (warnings, automatic control)". No information on system effectiveness or measure of system performance was included. Performance measures based on technological implementation would be reflected when estimating system effectiveness.

- Two systems provided both audio and visual warnings to the driver.
- Two systems provided only a visual alert to the driver.
- One system provided only an auditory warning to the pedestrian.[21]

To estimate the effectiveness and potential safety benefits for a warning component, information is needed about system performance (i.e., warning time) and driver response to a warning (i.e., reaction time and braking level).

1.3.2 Automatic Braking System

Braking systems automatically apply the vehicle brakes in imminent crashes when the driver does not respond appropriately (i.e., no driver response or not enough braking). Two distinct automatic braking systems were identified:

- AEB: applies maximum braking pressure, independent of driver input in some implementations.
- Dynamic Brake Assist (DBA): increases the driver-applied braking pressure to maximum braking levels to assist the driver.

Five systems activated the vehicle brakes after the warnings were issued: three AEBs and two DBAs. A single system activated the brake assist only without any warning.

To estimate the effectiveness and potential safety benefits for automatic braking systems, information is needed about system performance (i.e., activation time and braking level) and basic braking logic (i.e., interaction with driver braking input). For example, a DBA system may require driver input to activate (i.e., DBA would support the driver once the driver activated the brakes). An AEB system may not require driver input and may activate automatically in the absence of driver input. Further, some systems implement braking suppression techniques to avoid nuisance or false activations of automatic braking. These suppression techniques may use driver brake input as an assumption that the driver is alert and in control.

1.3.3 Automatic Steering System

Steering systems provide automatic steering to avoid a potential crash. Under valid conditions (e.g., no object in the areas near the pedestrian), the vehicle may steer away from the pedestrian into an unoccupied lane.

Two systems were found to have steering systems that supplement warning and automatic braking. Due to complexity, limited system information, and the fact that this is not a near-term system in the United States, the automatic steering system is not considered in this report.

[21] Pedestrian reactions and motions are erratic, sudden, and unpredictable, therefore this warning method was not considered in this analysis. To incorporate this feature, more information and research on pedestrian motions, reactions, and speeds in vehicle-pedestrian conflicts and warning reactions are needed.

1.3.4 Estimating Benefits for PCAM Countermeasures

After assessing the various PCAM profiles and available sources of data, this analysis considers the potential safety benefits for the following three PCAM systems:

1. AEB only systems,
2. Warning + first braking response between AEB or driver, and
3. Warning + best braking response between AEB and driver.

AEB would provide a lower-limit range of potential safety benefits; any additional and early driver input could yield higher benefits (i.e., earlier braking response). Test data are available for AEB activation and braking levels from track characterization tests of production vehicles.

Incremental benefits are determined by adding driver response to a warning issued prior to AEB activation. For example, in an imminent vehicle-pedestrian crash, a system would alert the driver via warning that a crash was imminent. This warning would elicit a driver response, however if a driver does not respond in time, brake hard enough, or not at all, AEB may initiate. This driver-vehicle interaction requires further research and input. Accounting for driver behavior requires information on conflict start (i.e., warning time), driver reaction time, driver braking level, and system suppression methods (i.e., automatic braking interaction with driver brake input). To encompass potential system suppression methods, two logic systems are implemented when both driver and AEB are activated. The following two system logic methods were implemented:

1. First Braking - Assumes that once braking has been initiated (by driver or AEB), it remains constant for the remainder of the event, regardless of magnitude. This assumes that any initial response suppresses secondary responses (i.e., driver is in control means no AEB necessary or AEB activate assumes driver will never respond).
2. Best Braking – Assumes that if both braking inputs are active (driver and AEB), the system uses the higher input to maximize braking effectiveness. If only one braking input is active (AEB or driver), then the system uses the active input. This system attempts to maximize effectiveness with the earliest and best braking response.

Based on the logic above, these two systems will still initiate if no driver braking is initiated.

1.4 Relevant Pedestrian Research

A literature review was performed to gather information from previous research on safety benefit estimation techniques and results for PCAM systems.

1.4.1 Pedestrian Injury Mitigation by Automatic Braking

This research calculated the effectiveness of a pedestrian injury mitigation system that would automatically apply the vehicle brakes at one second prior to impact with a pedestrian [6]. All pedestrians who were within a given field-of-view (FOV), but not obstructed by surrounding objects (e.g., other vehicles or fixed objects such as buildings), were assumed to be detected by the system. The analysis included 243 cases from the 1999-2003 German In-Depth-Accident-

Study (GIDAS) for pedestrians hit by the front of a passenger car, sport utility vehicle, minibus, or van. A weighting factor was applied to the GIDAS data so that it would better resemble the total German population of pedestrian crashes. The measure used to calculate the effectiveness was based on the reduction of fatally and severely injured pedestrians. Fatality risk curves were created as a function of impact speed for baseline and system cases. New impact speeds in system crashes were determined based on estimates of certain parameters (e.g., would the system detect the pedestrian less than 1 second prior to impact? Did the driver brake?) A sensitivity analysis was also included in this research, which altered the impact speed by ±10 percent, the deceleration achieved by the actual drivers by ±10 percent, the angle to pedestrians by ±10 percent, and the choice of fatality risk curve.

The results showed that the effectiveness at reducing fatally (severely) injured pedestrians in frontal collisions with cars reached 40 percent (27% in severely injured) with a 40-degree FOV. Increasing the FOV further led to only marginal improvements in effectiveness. The average braking duration for drivers was 0.67 second, whereas the automatic braking system (≤ 0.6 g) had an average braking duration of 1.4 seconds. Nearly 80 percent of the fatality reduction came from cases where the driver had not braked.

Further, this research reports that predictive studies depend on the representativeness of the used data set. However, the weighting applied to the GIDAS data had only a slight influence on the derived effectiveness. The research claims that the results were stable against changes in the risk curves. Additionally, the results were stable against changes in impact speed, mean driver braking deceleration, and pedestrian location one second prior to impact. These findings indicate that the applied statistical methods were robust when applied to this particular data set.

1.4.2 Potential Head Injury Reducing Benefit of Combining Passive and Active Pedestrian Protection Systems

This report looked at the benefits of using passive (deployable airbag) and active (automatic braking) countermeasures to mitigate head injuries in pedestrian impacts [7]. This research used GIDAS data (68 cases) and included system effectiveness equations based on frontal impacts with pedestrians with severely injured heads. The harm measure was based on head injuries equivalent to an abbreviated injury scale (AIS) of 3 and above. Risk curves were based on impact speed. An average value of 48.7 km/h (30.3 mph) was observed in target cases. Determination of the pedestrian’s visibility and the vehicle impact speeds were collected. The automatic braking system was activated at one second prior to impact. Speed reduction based on simulation and risk reductions were calculated and used in a formula to sum up the cases and estimate the system effectiveness. The effectiveness estimations were presented for the active, passive, and integrated (active and passive) countermeasure systems. Results showed that the integrated system had an increased potential to reduce pedestrian head injuries as compared to either the active or passive system used alone. Effectiveness values ranged from 11 percent to 64 percent depending on the countermeasure parameters or the type of system modeled: active, passive, or integrated.

1.4.3 Next Generation EyeSight® and Future Strategy

EyeSight® is a safety technology developed in 2008 that, among other features, uses a stereo camera to detect pedestrians and bicycles to provide collision avoidance [8]. EyeSight® version 2 was developed in 2010. Both systems use AEB collision avoidance technology for speeds up to 30 km/h (18.6 mph). EyeSight® version 3, developed in 2014, can provide AEB collision avoidance at speeds up to 50 km/h (31 mph). Crash data from the Institute for Traffic Accident Research and Data Analysis (Japan) (ITARDA) were compiled for vehicle-pedestrian crashes with and without EyeSight® version 1 and version 2 equipped vehicles. Table 3 shows counts for vehicles equipped with EyeSight® and the number of crashes, as well as for those not equipped with EyeSight®. Simple effectiveness calculations[22,23] show a 75 percent effectiveness based on pedestrian crashes for version 1 and an 88 percent effectiveness for version 2. ***Volpe performed these effectiveness calculations based on the number of vehicles equipped and the number of crashes provided in the EyeSight® report. This report did not provide further information on the details of the crashes***. A survey of U.S. customers about their deactivation of the system revealed that the most common reason for deactivation of the EyeSight® system is low sun angle (80%), followed by heavy precipitation (44%) and fog (17%).

Table 3: Number of Vehicles Equipped with EyeSight® and Number of Crashes

System	Vehicles	Crashes	Crash/Vehicle	Ped. Crashes	Ped. Crash/Vehicle
With EyeSight v1	2,165	29	0.013	3	0.0014
Without EyeSight v1	30,039	1,997	0.066	169	0.0056
Effectiveness			**80%**		**75%**
With EyeSight v2	171,069	576	0.003	90	0.0005
Without EyeSight v2	27,886	1,168	0.042	124	0.0044
Effectiveness			**92%**		**88%**

1.4.4 Automatic Emergency Braking on Pedestrian –Target System Development and Challenges of Testing

The 2015 Society of Automotive Engineers Government/Industry meeting in Washington, DC involved a breakout session that discussed testing methods and ratings for crash avoidance systems.[24] During the session, Dr. Frank Baumann discussed the process and challenges of developing a vehicle-pedestrian crash test for AEB systems. Dr. Baumann emphasized several key points based on his own professional experience, expertise, and opinion:

- Pedestrians show highly dynamic behavior and can stop/turn immediately.
- Early emergency braking activation may not be accepted by drivers in certain situations such as, if a pedestrian stops immediately before crossing the road.

[22] Based on ratios of crash rates for vehicles equipped with EyeSight® compared to those without EyeSight®.

[23] $$Effectiveness = \frac{\# \, Crashes \, with \, \text{EyeSight®}}{\# \, Vehicles \, with \, \text{EyeSight®}} \bigg/ \frac{\# \, Crashes \, without \, \text{EyeSight®}}{\# \, Vehicles \, without \, \text{EyeSight®}}$$

[24] www.sae.org/events/gim/2015/

- Emergency braking systems need to be designed conservatively in order to only activate if a crash is imminent.
- Performance expectations on emergency braking systems on pedestrians need to consider potential false positives.
- Trade-off between performance and potential false activations must be considered [9].

These key points can be considered in modeling safety benefits since they create variations in performance, acceptance, and effectiveness estimates as PCAM systems are deployed in the real-world fleet.

1.4.5 Pedestrian Pre-Collision System (PCS) Research

This research presented naturalistic driving data that described pedestrian behaviors [10]. The data encompassed 110 vehicles that traveled 1.44 million miles in Indianapolis for one year. There were a total of 1,762 videos of potential conflicts with pedestrians. A distribution of time-to-collision (TTC) versus the number of cases was calculated and cumulative results were shown. The mean value for TTC when a vehicle-pedestrian conflict began was 4.43 seconds. The lateral distances from the left and right side of the vehicle to the pedestrian (at the appearance point) were also calculated. The mean left-side lateral distance was 6.55 meters and the mean right-side distance was 5.21 meters.

In addition to field tests, this research conducted track tests using a vehicle equipped with a stereo camera and millimeter-wave radar to detect pedestrians. Test scenarios varied according to pedestrian direction, vehicle motion, light condition, pedestrian size, and pedestrian motion. The vehicle-turning avoidance rate was 84 percent. The mannequin darting (running) avoidance rate was 35 percent. Other avoidance calculations were presented representing various scenarios/vehicles and testing conditions.

1.4.6 The EURO NCAP VRU[25] Pedestrian AEB Test Procedure –Initial Test Results and Future Research

The European New Car Assessment Program (EURO NCAP) has devised and developed three vehicle-pedestrian pre-crash scenarios for initial vehicle testing [11]. These pre-crash scenarios are derived for real-world data and will help dictate future research in Europe. The three scenarios are described in Table 4 below.

[25] Vulnerable road user

Table 4: Description of Test Scenarios

Test	Pedestrian			Vehicle			
	Size	Direction[26]	Speed	Motion	Speed	Impact Overlap[27]	Obstructed View?
1	Adult	Right-Left	Walking 5 km/h (3.1 mph)	Straight	20 - 60 km/h (12.4 - 37.3 mph)	25% & 75%	No
2	Child	Right-Left	Running 5 km/h (3.1 mph)	Straight	20 - 60 km/h (12.4 - 37.3 mph)	50%	Yes
3	Adult	Left-Right	Running 8 km/h (4.9 mph)	Straight	20 - 60 km/h (12.4 - 37.3 mph)	50%	No

1.4.7 Comparison of Methods

By comparing the methods from the literature, along with previous Volpe research, there are many elements that are commonly used [2]. For example, crash databases are imperative to understanding the dynamics of vehicle-pedestrian crashes. The German crash database, GIDAS is far more extensive in detail compared to NHTSA's GES and FARS crash databases. Parameters of interest are briefly described below:

- Crash data – Understanding of the crash data provides valuable information, including pre-crash scenarios, initial conditions, and baseline measures.
- Harm curves – Derived from historical crash data to correlate impact speed to injury, these curves quantify benefits (e.g., crashes, fatalities, and injuries).
- Operational capabilities – Understanding the capability of the PCAM system can account for issues such as obstructions, bad weather, speed thresholds, and overall technological capability.
- Driver and system performance data – Incorporate driver performance (e.g., reaction time and braking level) and system performance (e.g., activation times of 1 second TTC, braking levels). Accounting for warnings and/or automatic emergency braking will vary the benefits estimation technique and required data.
- Crash reconstruction/PCAM simulation – Superimpose the PCAM system over historical crashes (reconstructed, probability of baseline crash = 1) or similar crashes in a simulation (probability of a baseline crash ≠ 1). Reconstructions use hypothetical systems when real-world test data are not available.
- Crash avoidance and/or speed reduction – These measures drive system effectiveness and safety benefits.

All benefits estimation techniques require a basic methodology and detailed data.

[26] As viewed from the driver of the test vehicle
[27] Impact point as a percentage of vehicle width and pedestrian direction

2 BENEFITS ESTIMATION METHOD

PCAM systems have the potential to provide annual safety benefits by avoiding a vehicle-pedestrian crash completely or by mitigating pedestrian injury by reducing the vehicle impact speed. Safety benefits are determined from PCAM system effectiveness and are expressed in terms of reductions in the number of crashes or the number of pedestrians injured. The general methodology for estimating the safety benefits in this report is derived from a method previously used for vehicle-to-vehicle (V2V) based crash warning systems [12]. This method supported NHTSA research efforts for assessing the status of V2V technology and future research needs [13]. Further, this method is supported by previous pedestrian research that detailed target crash scenarios for PCAM systems and also developed a methodology to estimate their potential safety benefits [2].

2.1 Equations

2.1.1 Crash Avoidance

The general equation of safety benefits and system effectiveness is presented in Equation **(**1**)** and estimates the potential safety benefits in annual crash reduction [14].

$$\boldsymbol{B_A = N_C \times E_A} \tag{1}$$

Where:
$\boldsymbol{B_A}$≡ Reduction in annual baseline target crashes in a pre-crash scenario by a PCAM system
$\boldsymbol{N_C}$≡ Annual number of baseline target crashes in a pre-crash scenario
$\boldsymbol{E_A}$≡ Crash avoidance effectiveness of a PCAM system in its target pre-crash scenario

Statistics of baseline target crashes, $\boldsymbol{N_C}$, are determined from NHTSA's GES and FARS crash databases. Crash avoidance effectiveness, $\boldsymbol{E_A}$, uses historical crash data along with driver/vehicle/system performance data. The data are input into simulations that aid in this effectiveness estimation. Crash avoidance effectiveness, $\boldsymbol{E_A}$, is estimated by Equation **(**2**)**.

$$\boldsymbol{E_A = 1 - ER \times PR} \tag{2}$$

Where:
$\boldsymbol{ER}$ ≡ Exposure Ratio, ability of a PCAM system to reduce the encounter with target pre-crash scenario conflict in normal driving behavior
$\boldsymbol{PR}$ ≡ Prevention Ratio, ability of a PCAM system to reduce the likelihood of a crash given that a vehicle enters a pre-crash scenario conflict

Exposure ratio, $\boldsymbol{ER}$, is the ability of a system to reduce the occurrence of conflicts in normal driving, typically derived from long-term naturalistic driving [15]. For example, consider a vehicle intending to turn left at an intersection. As the vehicles begins to initiate the turn, a pedestrian may walk into vehicles intended path. The driver's view may be obstructed by an object within the vehicle (e.g., A-pillar). Without a PCAM system, the driver may attempt the turn and enter into a conflict with a pedestrian crossing road. However, with a PCAM system, a warning may alert the driver that a pedestrian is present and the driver may allow the pedestrian to cross prior to initiating or completing the turn. A system may reduce the occurrence of these conflicts, providing a safety benefit. $\boldsymbol{ER}$ estimates typically come from long-term field operational tests, collecting data on naturalistic driving behavior without a system (baseline) and then with a system (treatment). However, due to the lack of available naturalistic driving data for vehicle-pedestrian conflicts in baseline and treatment conditions, $\boldsymbol{ER}$ is conservatively set to 1**;** **(*ER* = 1)**. That is, driving behavior does not change with the introduction of a PCAM system and the number of conflicts encountered remains the same.

The crash prevention ratio, $\boldsymbol{PR}$, is the ability of a PCAM system to reduce the likelihood of a crash, given that the vehicle has entered into a conflict [15]. This ratio is the ability of a PCAM system to avoid a crash. For example, consider the same vehicle turning scenario mentioned above. Without a PCAM system, the driver may impact the pedestrian. However, with a PCAM system, the vehicle may brake earlier and stronger (via driver response or automatic control) and avoid the collision. The values for $\boldsymbol{PR}$ can be derived from crash databases and simulations with input driver/vehicle/system performance data. Equation **(**3**)** breaks down the $\boldsymbol{ER}$ and $\boldsymbol{PR}$ terms from Equation **(**2**)**.

$$\boldsymbol{E_A = 1 - \frac{EM_{PCAM}}{EM_{Base}} \times \frac{CP_{PCAM}}{CP_{Base}}} \qquad \textbf{(3)}$$

Where:

$\boldsymbol{EM_{PCAM}}$ ≡ Exposure Measure to a driving conflict corresponding to a target scenario in treatment condition

$\boldsymbol{EM_{Base}}$ ≡ Exposure Measure to a driving conflict corresponding to a target scenario in baseline condition

$\boldsymbol{CP_{PCAM}}$ ≡ Crash Probability when exposed to a driving conflict corresponding to a target scenario in treatment condition

$\boldsymbol{CP_{Base}}$ ≡ Crash Probability when exposed to a driving conflict corresponding to a target scenario in baseline condition

Crash probabilities in baseline conditions, $\boldsymbol{CP_{Base}}$ from Equation **(**3**)**, will be derived from historical crash data and therefore is equal to 1 **(**$\boldsymbol{CP_{Base} = 1}$**)**. This value is true when a crash reconstruction method is used to estimate the crash probabilities with a PCAM system, $\boldsymbol{CP_{PCAM}}$ in Equation **(**3**)**. This technique involves a simulation that reconstructs available historical crashes and superimposes driver/vehicle/system performance data in treatment conditions to determine the results when a PCAM system is introduced. Based on the above assumptions, Equation **(**3**)** is simplified to Equation **(**4**)**; $\boldsymbol{EM_{PCAM}}$ = $\boldsymbol{EM_{Base}}$, and $\boldsymbol{CP_{Base}}$ = 1.

$$\boldsymbol{E_A = 1 - CP_{PCAM}} \qquad \textbf{(4)}$$

Table 5 below describes the terms needed to estimate the crash avoidance effectiveness, their sources, and value.

Table 5: Variables and Potential Data Sources to Estimate Crash Avoidance Effectiveness and Benefits

Eq. #	Var.	Var. Name	Source	Value
1	N_C	Target crashes	Crash databases (GES and FARS)	TBD
2	ER	Exposure Ratio of PCAM to Baseline	Naturalistic driving data (field tests)	1
3	CP_{PCAM}	Crash probability (PCAM)	Driver/system/performance data	Simulation
3	CP_{Base}	Crash probability (Baseline)	Crash databases (GES and FARS)	1

2.1.2 Crash Mitigation

In addition to crash avoidance, a PCAM system may reduce any resulting harm to the pedestrian by reducing the vehicle's travel speed prior to impact through faster driver response or automatic vehicle control. Similar to Equation **(**1**)**, the equation to estimate the reduction in pedestrian injury is provided in Equation **(**5**)**.

$$\boldsymbol{B_M = N_I \times E_M = N_I \times \{E_A + E_W \times (1 - E_A)\}} \qquad \textbf{(5)}$$

Where:

$\boldsymbol{B_M}$ ≡ Reduction in annual baseline number of pedestrians injured in a pre-crash scenario by a PCAM system

$\boldsymbol{N_I}$ ≡ Annual number of baseline pedestrians injured from target crashes in a pre-crash scenario

$\boldsymbol{E_M}$ ≡ Injury mitigation effectiveness of a PCAM system in a target pre-crash scenario

$\boldsymbol{E_W}$ ≡ Injury reduction effectiveness in non-avoidable crashes in a target pre-crash scenario

Equation **(**5**)** estimates the safety benefits of a PCAM system in terms of reductions in the number of injured pedestrians at different injury levels from prevented crashes (i.e., $\mathbf{N_I \times E_A}$) and from severity mitigation of non-avoided crashes (i.e., $\mathbf{N_I \times E_W \times (1 - E_A)}$). The latter is obtained from a reduction in impact speed. Statistics of baseline target injuries, $\boldsymbol{N_I}$, are determined from NHTSA's GES and FARS crash databases. Injury mitigation effectiveness, $\boldsymbol{E_M}$, uses historical crash data along with driver/vehicle/system performance data. The data are input into simulations to determine the impact speed when a crash occurs with a PCAM system. The parameter, $\boldsymbol{E_W}$, is computed as follows in Equation **(**6**)**:

$$\boldsymbol{E_W = 1 - \frac{H(PCAM)}{H(Base)}} \qquad (6)$$

Where:

H(PCAM) ≡ Harm sustained with PCAM intervention (treatment)

H(Base) ≡ Harm sustained without PCAM intervention (baseline)

Harm sustained, $\boldsymbol{H}$, is estimated from harm curves that represent the relationships between the probability of an injury and a given impact speed in specific crashes. Such relationships are derived from NHTSA crash databases, detailed in a subsequent section. The estimation of harm sustained for a target crash scenario in the baseline is determined from Equation (7).

$$\boldsymbol{H}(\boldsymbol{Base}) = \sum_{\mathbf{j=1}}^{\mathbf{j}} \boldsymbol{h}_{\mathbf{m}}\,(\mathbf{i}) \times \boldsymbol{o}_{\boldsymbol{Base}}(\mathbf{i}) \qquad \mathbf{(7)}$$

Where:

$\boldsymbol{h_m}$ ***(i)*** ≡ Average harm at injury level, ***m***, to a pedestrian struck in impact speed bin, ***i***

$\boldsymbol{o_{Base}}$ ***(i)*** ≡ Proportion of pedestrians struck in impact speed bin, ***i***, without PCAM intervention (baseline)

The distribution of pedestrians struck without PCAM intervention, $\boldsymbol{o_{Base}}$ ***(i)***, is queried directly from NHTSA crash databases. The average harm associated with a speed bin, $\boldsymbol{h_m}$***(i)***, is also determined from historical crash data. To determine the harm sustained for crashes with PCAM intervention, Equation (7) is modified to below:

$$\boldsymbol{H}(\boldsymbol{PCAM}) = \sum_{\mathbf{j=1}}^{\mathbf{j}} \boldsymbol{h}_{\mathbf{m}}\,(\mathbf{i}) \times \boldsymbol{o}_{\boldsymbol{PCAM}}(\mathbf{i}) \qquad \mathbf{(8)}$$

Where:

$\boldsymbol{o_{PCAM}}$ ***(i)*** ≡ Proportion of pedestrians struck in impact speed bin, ***i***, with PCAM intervention (treatment)

The same harm curve is associated with both baseline and treatment. The distribution of pedestrians struck with PCAM intervention, $\boldsymbol{o_{PCAM}}$***(i)***, is obtained from simulation results.

Using this technique, a simulation is used to estimate the probability of a crash and their resulting impact speeds when a PCAM system is introduced. Table 6 below describes the terms needed to estimate crash mitigation effectiveness and their sources.

Table 6: Variables and Potential Data Sources to Estimate Crash Mitigation Effectiveness and Benefits

Eq. #	Var.	Var. Name	Source	Value
5	N_I	Target Injured	Crash databases (GES and FARS)	TBD
7	o_{Base} (i)	Crash distribution (Baseline)	Crash databases (GES and FARS)	TBD
8	o_{PCAM} (i)	Crash distribution (PCAM)	Driver/system/performance data	Simulation
7 , 8	h_m (i)	Average ham distribution	Crash databases (GES and FARS)	TBD

2.2 Simulation Model

A Monte Carlo simulation model was used to estimate the crash probability of vehicle-pedestrian conflicts given specific initial conditions. The simulation model exercises general kinematic equations in conjunction with driver and system performance data to determine the probability of a crash and the resulting impact speeds given a crash. Kinematic equations were derived from previous research for the four priority pre-crash scenarios [5]. This simulation reconstructs historical 2011 and 2012 PCAM-addressable GES and FARS crashes and superimposes PCAM system and driver performance data to determine the outcome with PCAM intervention.

Initial conditions are described by vehicle location, size and speed, pedestrian location, size, and speed, and environmental conditions (i.e., lighting and obstructions). Driver and system performance data are described by driver reaction time, driver braking level, system activation time, and system braking level. These parameters are derived from various data sources; data source and input data are described in other sections. The results of the simulation model determine the crash probability, $\boldsymbol{CP_{PCAM}}$ from Equation **(**4**)**, and $\boldsymbol{o_{PCAM}\ (i)}$ from Equation (8).

Baseline parameters do not require a simulation model, as historical crashes will be reconstructed; therefore, the baseline crash probability is equal to 1 and the impact speed distribution is calculated directly from crash data.

2.3 General Assumptions

This analysis focuses on light-vehicles moving forward and striking a pedestrian in the first event, with the driver attempting no avoidance maneuver. The following assumptions are made in order to estimate system effectiveness and project potential safety benefits:

- All light-vehicles are fully equipped with PCAM sensing technology.
- <u>System performance</u>
  - Systems are analyzed independent of technological implementation.
  - All deployed systems are assumed to perform as they did when tested (with technology used and system algorithms). If specific testing was not done, than those testing conditions are assumed to be outside the operational boundaries of a PCAM system.
  - Only system performance degradation observed on the test track is incorporated (e.g., pedestrian speed and size affecting activation timing, obstructions affecting activation).
- <u>Computer modeling and simulation</u>
  - Simple driving conflicts are modeled using basic kinematic equations, where only the driver and vehicle respond to the conflict while the pedestrian stays the course.
  - No external conflicts or unintended consequences are modeled.
  - For a crash to occur, the vehicle must strike the pedestrian (pedestrian cannot strike vehicle).
  - The driver and vehicle respond with a single appropriate response (brake) while the pedestrian has no reaction and continues course at a constant rate.

    - All motion and reaction occur without intermittent delays or interference, and are constant until otherwise acted upon.
    - Changes in coefficient of friction due to changes in surface (wet, snow, ice, dirt, asphalt, etc.) are not modeled.
    - Pedestrians are initially assumed to impact the center of the front of the vehicle.
- <u>System Effectiveness and Benefits</u>
    - Effectiveness estimates are assessed from avoiding or mitigating the first event of the crash only. It is assumed that if the first event of the crash was avoided, all subsequent events would be avoided.
    - Crashes that did not meet operational boundaries of PCAM systems (i.e., light vehicle, impacting a pedestrian, first event of crash, vehicle moving forward, contact pedestrian with front of vehicle, no attempted avoidance maneuver), did not have information that correlated to system performance testing conditions, or did not have enough information to reconstruct were assumed to receive no benefit. Therefore system effectiveness and projected benefits were conservatively estimated to be 0 for these crashes.
    - All systems are assumed to be equally distributed amongst the fleet, assuming all light-vehicles are fully equipped with a PCAM system.

These general assumptions are carried throughout the safety benefits estimation methodology, independent of the pre-crash scenario. Furthermore, assumptions are made to specific pre-crash scenarios, details of which will be discussed in appropriate sections.

3 INPUT DATA

Safety is ideally measured using actual crash data from baseline and treatment driving conditions. However, in the current state of data, real-world crash data are not readily available to directly compare unequipped PCAM vehicles (baseline) to equipped PCAM vehicles (treatment). As described in Section 1.2 and Section 2, other sources can be used to determine the necessary input data to estimate safety benefits for PCAM systems.

3.1 National Vehicle-Pedestrian Crash Data

Historical crash data at the national level are available from NHTSA's GES and FARS crash databases. These crash databases contain variables, codes, and relevant statistics that help to quantify and characterize the pedestrian crash problem addressed by PCAM safety systems. PCAM-addressable crashes include crashes where a forward moving light-vehicle struck a pedestrian in the first event of the crash with the front of the vehicle and the driver attempted no avoidance maneuver. These databases provide estimates for the parameters $\boldsymbol{N_C}$ and $\boldsymbol{N_I}$ in Equations **(**1**)** and **(**5**)** for the potential safety benefits.

On average from 2011 to 2012, based on GES and FARS data query, there were approximately 62,917 vehicle-pedestrian crashes and 3,337 fatal vehicle-pedestrian crashes of interest for this report in the U.S. [5] [16]. These select crashes are for all vehicle-pedestrian crashes where a pedestrian was struck by a light-vehicle in the first event of a crash. On average, these crashes resulted in approximately 13,000 injured persons at the Maximum Abbreviated Injury Scale (MAIS) 2^+ levels and 7,000 injured pedestrians at MAIS 3^+ levels. Appendix A provides the matrix used to convert the injury levels from the police-reported KABCO scale in the GES database to the MAIS scale. The FARS was queried to get the actual count of persons killed in target crashes.

The crash databases also contain details to specifically characterize each crash, including pre-crash scenario, travel speeds, environmental conditions, driver factors, and attempted avoidance maneuvers. Details surrounding the crash allow for an accurate depiction of the driving conflict, supporting the estimation of $\boldsymbol{E_A}$ and $\boldsymbol{E_W}$ from Equations **(**1**)** and **(**5**)**.

3.1.1 Baseline Crashes

The six criteria for target baseline crashes for a PCAM system include:

1. Light-vehicle,
2. impacting pedestrian, with the
3. first event of crash, and
4. vehicle moving forward, with the
5. front of vehicle impacting the pedestrian, and
6. no attempted avoidance maneuver by the vehicle.

The above criteria aim to encompass the operational capabilities of PCAM systems and their aimed effectiveness. Due to limited information on system performance with driver input (e.g., driver pressing the brake pedal may suppress AEB activation), attempted avoidance maneuvers were not considered. Impaired drivers were considered for this analysis, as their alertness is not dependent on the activation of AEB; however impaired drivers may not react to a warning but the AEB component could still activate. The following definitions were used to obtain the target baseline crashes:

- Light-Vehicle: The use of the vehicle body type variable in the crash databases identified passenger cars, vans and minivans, sport utility vehicles, and light pickup trucks with gross vehicle weight rating less than 10,000 pounds.
- Pedestrian: Any person on foot, walking, running, jogging, hiking, standing still, sitting, or lying down, excluding any person on a personal conveyance such as personal mobility device or rideable toy.
- First Event: Crash data provide a series of critical events for the crash, regardless of injury or damage sustained (or lack thereof). The first listed critical event of the crash was used.
- Vehicle Moving Forward: Crash data provide pre-event movement of the vehicle, prior to the driver's realization of an impending critical event. Movements listed as no driver, stopped, backing, parking related, or unknown were excluded.
- Area of Impact: Crash data provide the area of impact of the vehicle. Only crashes that identified the front of the vehicle to be struck (i.e.., 11, 12, and 1 o'clock values) were considered.
- Avoidance Maneuver: Crash data provide the attempted avoidance maneuver of the vehicle in recognition of the critical pre-crash event. Only crashes with 'no avoidance maneuver' attempted by the vehicle were considered.

Table 7 shows the crash frequency broken down by vehicle-pedestrian pre-crash scenario given the criteria described above. Based on 2011 and 2012 data, an annual average of 21,090 GES crashes and 2,193 FARS crashes met the above criteria to be considered PCAM-addressable crashes. Table 8 shows the resulting injuries to the pedestrian identified in the first event of the crash, independent of crash database.[28] Based on the 2011 and 2012 data, an annual average of 5,376 pedestrians were injured at the MAIS 2^+ level and 3,305 were injured at the MAIS 3^+ level. The four priority pre-crash scenarios account for 90 percent of GES crashes and 96 percent of all MAIS 3^+ injuries.

Table 7: Breakdown of Average Annual Baseline PCAM-Addressable Crashes by Priority Pre-Crash Scenarios

Scenario	Vehicle Maneuver	Pedestrian Maneuver	GES Frequency	% GES Frequency	FARS Frequency	% FARS Frequency
S1	Going Straight	Crossing Roadway	7,481	35.5%	1,396	63.7%
S2	Turning Right	Crossing Roadway	2,264	10.7%	24	1.1%
S3	Turning Left	Crossing Roadway	6,200	29.4%	87	4.0%
S4	Going Straight	Walking Along/Against Traffic	2,950	14.0%	620	28.3%
Other Scenarios			2,195	10.4%	66	3.5%
Total PCAM-Addressable Crashes			**21,090**		**2,193**	

[28] To obtain MAIS injury levels, a conversion matrix was used, as described in Appendix A. To obtain these estimates, the GES and FARS databases were combined by inserting the observed fatalities from FARS (Injury Severity = Fatal (K)) into the estimated fatalities within GES for a given pre-crash scenario. These injuries were then converted to MAIS estimates.

Table 8: Breakdown of Average Annual PCAM-Addressable Injured Pedestrians by Priority Pre-Crash Scenarios

Scenario	Vehicle Maneuver	Pedestrian Maneuver	MAIS 2+	% of MAIS 2+	MAIS 3+	% of MAIS 3+
S1	Going Straight	Crossing Roadway	2,682	49.9%	1,879	56.9%
S2	Turning Right	Crossing Roadway	274	5.1%	92	2.8%
S3	Turning Left	Crossing Roadway	883	16.4%	333	10.1%
S4	Going Straight	Walking Along/Against Traffic	1,207	22.4%	860	26.0%
Other Scenarios			330	6.1%	141	4.3%
Total Injuries from PCAM-Addressable Crashes			5,376		3,305	

National crash databases contain an abundance of cases but lack detailed information on the dynamics of the crash. These databases rely on available police-reports and witness statements to detail the pre-crash information (e.g., motions, speed, and critical events). For example, approximately three quarters of GES cases that could be addressed by PCAM systems do not have travel speed information; it is coded as “unknown.” Further, detailed information on the pedestrian motion is not readily available. It is unknown whether the pedestrian was traveling left-to-right or right-to-left of the vehicle, when crossing the road. From the available information, it is not feasible to accurately determine the exact dynamics of the crash. A crucial missing element is the amount of time the pedestrian spent in view of the driver/vehicle, within the roadway, and in the vehicle’s intended path (TTC as soon as the collision was possible or when the pedestrian was revealed to the driver). For maximum effectiveness, PCAM systems may attempt to maximize accuracy and responsiveness (e.g., a pedestrian stepping off the sidewalk into the road between two parked cars), while minimizing the number of nuisance and false activations (e.g., a pedestrian standing on a sidewalk or a pedestrian standing behind a parked car). National crash databases do not have this information readily available. NHTSA tasked a special crash investigation (SCI) team to investigate the detailed dynamics of an S1 scenario.[29] Specifically, this SCI team was tasked to determine the TTC, or reveal time of pedestrian, for available vehicle-pedestrian crashes. Additionally, while these cases were being examined, further information could be obtained for future reference and research.

The resulting database contains over 50 recorded variables for 43 relevant vehicle-pedestrian crashes where investigators were able to examine the crash in detail and estimate a comprehensive list of details that depict the exact kinematics of the crash. Detailed information on this can be found in Appendix B. It is important to note that these 43 cases could not be incorporated into this methodology for numerous reasons (e.g., small sample size with wide range of results, bias towards severe injuries, not nationally representative) which are thoroughly explained in Appendix B. However, the data obtained provided detailed cases where PCAM could provide a benefit and justified the applicability of current PCAM systems to prevent crashes and save lives.

[29] S1 was selected due to its potential variations on circumstances, high frequency, and injury rates. It is assumed in S4 that the pedestrian is already walking or standing in the vehicle’s path, and therefore is limited by technological capabilities (e.g., a driver or PCAM system would be able to monitor an S4 situation as long as the pedestrian is within range).

Below, Figure 3 shows a breakdown of PCAM-addressable crashes from the national crash databases. Statistics are generated on an annual average for the 2011 and 2012 GES and FARS databases. Percentages are determined from the previous breakdown level. Each step is detailed in appropriate sections throughout the report. As seen from Figure 3, S1 and S4 combined account for:

- 10,431 crashes of all severities, comprising about 49% of all PCAM-addressable crashes or about 14% of all vehicle-pedestrian crashes.
- 2,016 fatal crashes, comprising about 92% of all fatal PCAM-addressable crashes or about 44% of all fatal vehicle-pedestrian crashes.
- 3,889 MAIS 2^+ injured pedestrians, comprising about 72% of all injured pedestrians in PCAM-addressable crashes or about 23% of injured pedestrians from all vehicle-pedestrian crashes.
- 2,739 MAIS 3^+ injured pedestrians, comprising about 83 of all injured pedestrians in PCAM-addressable crashes or about 30% of injured pedestrians from all vehicle-pedestrian crashes.
- $20,297,000,000 in comprehensive costs, comprising about 87% of all PCAM-addressable crashes or about 37% of all vehicle-pedestrian crashes (S1 accounts for $14,071,500,000 while S4 accounts for $6,225,700,000).

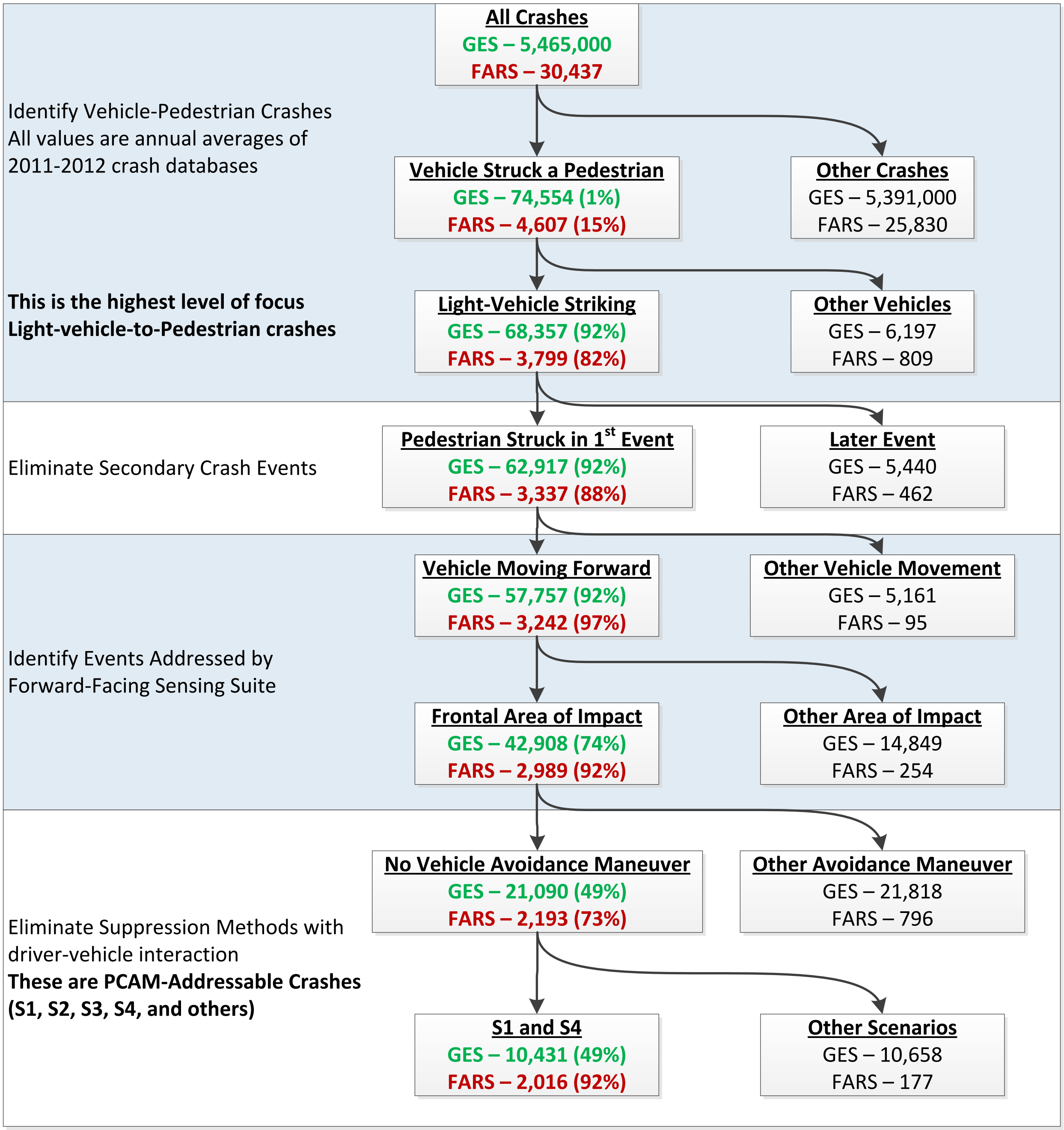

Figure 3: Breakdown of Crash Statistics for Vehicle-Pedestrian and PCAM-Addressable Crashes

3.1.2 Pedestrian Injury Probability Curves

Injury probability curves predict the probability of a pedestrian injury occurring given an impact speed. These curves are used to measure crash severity by correlating injury levels to impact speeds from historical crashes.

Injury probability curves were derived from 2011 and 2012 GES and FARS data. Crash data were queried for a light-vehicle moving forward, striking a pedestrian with the front of the vehicle in the first event, and attempted no avoidance maneuver. The vehicle travel speed and resulting pedestrian injury were obtained to determine the injury probability for five-mph incremental speed bins.[30] Table 9 shows the resulting probability of injuries for the various MAIS levels and speed bins. It is important to note, that travel speed information is mostly unavailable in the GES and FARS data where approximately 80 percent of crashes had unknown travel speed information.

Table 9: Probability of Pedestrian MAIS Level Given Impact Speed

Speed Bin (mph)		Probability of MAIS Level					
		pMAIS 1^+	pMAIS 2^+	pMAIS 3^+	pMAIS 4^+	pMAIS 5^+	pMAIS 6
1	0 < x ≤ 5	0.83	0.14	0.04	0.02	0.01	0.01
2	5 < x ≤ 10	0.83	0.13	0.04	0.02	0.01	0.01
3	10 < x ≤ 15	0.84	0.15	0.06	0.03	0.02	0.02
4	15 < x ≤ 20	0.90	0.25	0.12	0.06	0.04	0.03
5	20 < x ≤ 25	0.89	0.23	0.11	0.06	0.05	0.05
6	25 < x ≤ 30	0.87	0.24	0.13	0.09	0.08	0.08
7	30 < x ≤ 35	0.95	0.40	0.29	0.23	0.22	0.21
8	35 < x ≤ 40	0.96	0.57	0.49	0.46	0.45	0.44
9	40 < x ≤ 45	0.97	0.62	0.51	0.43	0.40	0.39
10	45 < x ≤ 50	0.96	0.54	0.45	0.41	0.40	0.40
11	50 < x ≤ 55	0.99	0.89	0.87	0.86	0.86	0.85
12	55 < x ≤ 60	1.00	1.00	1.00	1.00	1.00	1.00
13	60 < x ≤ 65	1.00	1.00	1.00	1.00	1.00	1.00
14	65 < x ≤ 70	1.00	0.93	0.91	0.89	0.88	0.88
15	70 < x ≤ 75	1.00	1.00	1.00	1.00	1.00	1.00
16	75 < x	1.00	1.00	1.00	1.00	1.00	1.00

The probability for a certain injury level is simply the difference of two $MAIS^+$ probabilities. For example, $p_{MAIS1} = p_{MAIS1+} - p_{MAIS2+}$ and $p_{MAIS2} = p_{MAIS2+} - p_{MAIS3+}$. The injury mitigation analysis in this report focuses on the MAIS 2^+ and MAIS 3^+ injury levels.

Results found in Table 9 are fed into a regression model to determine functions for the various harm curves. Equation **(9)** was used as the baseline equation to determine the functions.

---

30 Travel speed may not be equivalent to impact speed; however, crash databases do not contain impact speed. Travel speed is the vehicle's speed prior to conflict and could be used if no attempt to avoid a crash was made.

$$pMAIS(i) = \frac{1}{1 + e^{\alpha(-i+\beta)}} \quad \textbf{(9)}$$

Where:
$\boldsymbol{i}$ ≡ Ordinal value of the impact speed bin

Smoothed curves from developed functions help mitigate anomalies found with smaller data sets and aid in eliminating unusual spikes in data. For example, speed bin 14 in Table 9 has an unusual drop in probability, most likely due to the small sample size for that speed bin. The $MAIS^+$ injury severity variable is the dependent variable and the impact speed bin is the independent variable. Table 10 shows the results from the logistic regression model for $MAIS^+$ injury severity, the corresponding coefficients, and R^2 estimates.

Table 10: Results from the Regression Model Describing Pedestrian Injury Probability Curves

Injury Level	α	β	R^2
$pMAIS\ 1^+$	0.22	-5.40	0.80
$pMAIS\ 2^+$	0.44	7.68	0.96
$pMAIS\ 3^+$	0.57	8.71	0.96
$pMAIS\ 4^+$	0.65	9.12	0.94
$pMAIS\ 5^+$	0.67	9.22	0.94
pMAIS 6	0.68	9.26	0.94

Pedestrian injury probability curves feed into Equations (7) and (8) to determine the harm sustained within a target crash scenario. Figure 4 depicts the pedestrian injury probability curves based on Equation **(**10**)** and results from Table 10.

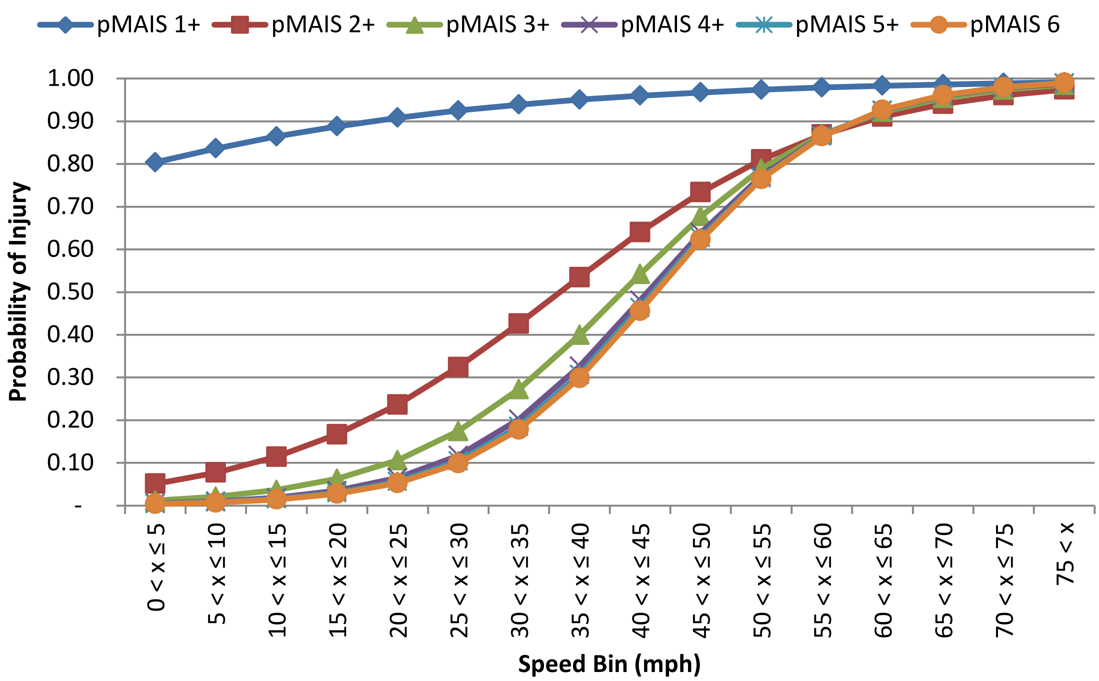

Figure 4: Plots of Pedestrian Injury Cumulative Probability Functions

3.2 PCAM System Performance

To estimate system performance of PCAM systems, results from characterization test runs were analyzed for use in the PCAM simulation. Tests were conducted at the Transportation Research Center Inc. (TRC) in East Liberty, Ohio, by NHTSA's Vehicle Research and Test Center (VRTC) [17]. Based on the target crashes discussed earlier, only S1 and S4 were tested.

3.2.1 Production Vehicles

Three production PCAM systems from three separate original equipment manufacturers (OEMs) were used to test PCAM system performance. The PCAM systems in these vehicles differed in system implementation (e.g., technology used and algorithms); however, they were all tested for their warning and AEB capability. Table 11 lists the number of test runs and describes the characteristics of each PCAM system.

Table 11: Number of Test Runs and Descriptions of PCAM Systems

PCAM System	# Test Runs	Technology	PCAM Min Speed (mph)	PCAM Max Speed (mph)	PCAM Max Detection Range (m)
OEM 1	562	Radar & Stereo Camera	4	Unknown	Unknown
OEM 2	657	Stereo Camera	1	100	79.6
OEM 3	450	Radar & Stereo Camera	5	31	Unknown

These three PCAM-equipped vehicles were tested in the S1 pre-crash scenario "vehicle going straight and pedestrian crossing the road" and two variations of the S4 pre-crash scenario:

1. Vehicle going straight and pedestrian standing in the road
2. Vehicle going straight and pedestrian walking along the road in the vehicle's path

These three test scenarios were varied slightly to characterize the systems. Variations and results are detailed in subsequent sections.

3.2.2 Characterization Test Setup

The PCAM system tests were conducted on a closed track at TRC. The tests involved a test vehicle driving down a straight, flat road towards a pedestrian mannequin, as seen in Figure 5.

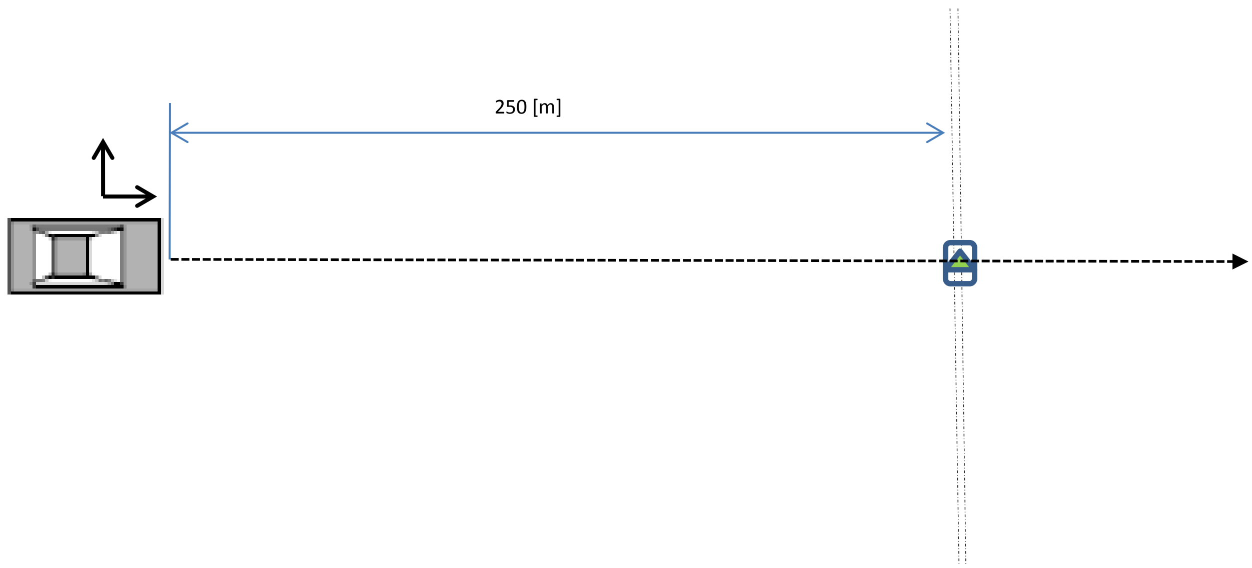

Figure 5: Test Schematic for PCAM Systems

The goal was to characterize the capabilities of PCAM systems in OEM vehicles to detect the mannequin and for the vehicle to issue a warning and automatically brake to avoid the crash. The tests were set up as follows:

1. The driver begins at least 250 m from the mannequin and accelerates to the prescribed vehicle speed, beyond the activation range of the PCAM system. The driver then maintains this constant speed throughout the test.
2. The mannequin is released at specified times to ensure impact with the vehicle with the prescribed overlap. The timing is calculated based on current trajectory and no countermeasure. The rig is programmed so that the mannequin impacts the 25 percent, 50 percent, or 75 percent location on the test vehicle, as shown in Figure 6.[31] The mannequin continues on the trajectory and speed throughout the test.

[31] Percent overlap is dependent on pedestrian direction. Pedestrians may be traveling left-to-right of the vehicle or right-to-left of the vehicle.

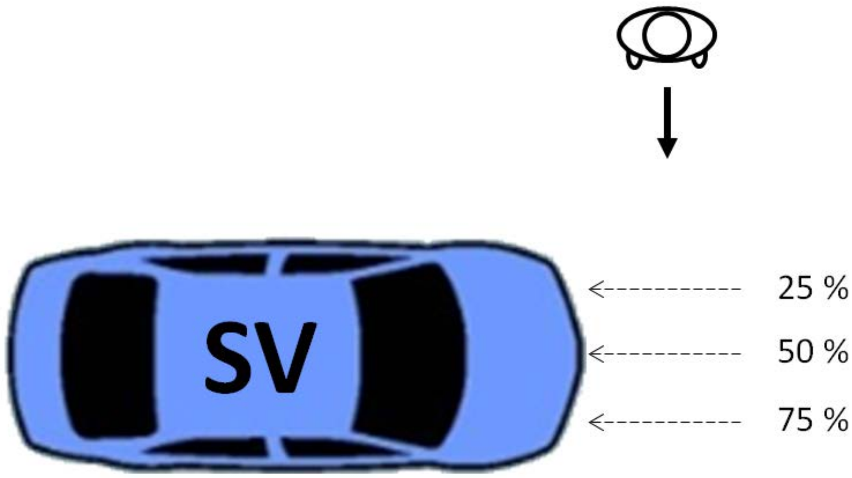

Figure 6: 25th, 50th, and 75th Percent Impact Locations on the Test Vehicle

3. As the vehicle approaches the impact location, the driver maintains constant speed and allows for the AEB system to activate (or not activate). The result, crash or no crash, is then recorded along with system performance (e.g., warning timing, AEB activation timing, and vehicle speed through time).[32]
4. The test is reset and repeated.

3.2.3 System Performance Variables

During testing, numerous conditions were modified in order to fully characterize each PCAM system. Conditions that were varied included scenario attributes (programmed impact location and obstructions), pedestrian attributes (size, clothing, speed, gait,[33] and direction), and vehicle attributes (speed). Various combinations of the conditions are summarized in Table 12 and a full detailed list of each condition and variable are described in Appendix C.

Measured results from the 1,600+ test runs were used to evaluate the performance of the PCAM systems. These results include crash/no crash outcome, warning time, AEB activation timing, and AEB average deceleration level. Results were categorized according to the various conditions listed earlier. Table 13 lists the variables measured for analysis.

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[32] In an S1 scenario, the crash can be avoided by stopping prior to the impact location or by slowing the vehicle enough so that the pedestrian can clear the impact location prior to the vehicle entering the impact location.

[33] Gait refers to the profile of the mannequin and the movement, or lack thereof, within the mannequin's joints.

Table 12: Variations of PCAM Testing Conditions

Pedestrian		Pedestrian Travel Direction /Orientation				Lighting		Obstruction*		Impact Overlap			Vehicle Speed (mph)			
Target	**Speed**	**S1 Right-Left**	**S1 Left-Right**	**S4 Facing Vehicle**	**S4 Away Vehicle**	**Day**	**Day To Night**	**Yes**	**No**	**25%**	**50%**	**75%**	**5 To 15**	**15 To 25**	**25 To 35**	**35 To 45**
Adult	3.1 mph	X			X	X			X	X	X	X	X	X	X	X
	4.9 mph	X				X			X	X	X	X	X	X		
	Stationary			X	X	X			X	X			X	X	X	X
Child	3.1 mph	X				X		X	X		X		X	X	X	X

*Obstruction tests were only conducted with a child mannequin

Table 13: PCAM System Performance Measures

Test Result Variable	Description
Impact	Was there a vehicle striking pedestrian impact?
Vehicle Speed at TTC of 4.0s	Measured steady-state vehicle speed at TTC = 4.0 s (mph)
Vehicle Distance to Target at TTC of 4.0s	Measured longitudinal range at TTC = 4.0 s (meters)
Pedestrian Speed at Lane Entrance	Measured pedestrian speed when pedestrian enters the lane that the vehicle occupies (mph)
Pedestrian Speed at Lane Exit	Measured pedestrian speed when pedestrian exits the lane that the vehicle occupies (mph)
Pre Warning Average Vehicle Speed	Measured average speed of the vehicle prior to Warning (mph)
Time to Target at Warning	Measured longitudinal TTC at Warning (seconds)
Vehicle Distance to Target at Warning	Measured longitudinal range at Warning (meters)
Pedestrian Distance From Center at Warning	Measured pedestrian position at Warning. Distance is referenced from center of test lane (meters)
Pedestrian Speed at Warning	Measured pedestrian speed at Warning (m/s)
Time to Target at AEB	Measured longitudinal TTC at the onset of vehicle AEB (seconds)
Vehicle Distance to Target at AEB	Measured longitudinal range at the onset of vehicle AEB (meters)
Pedestrian Distance from Center at AEB	Measured pedestrian position at onset of vehicle AEB. Distance is referenced from center of test lane (meters)
Pedestrian Speed at AEB	Measured pedestrian speed at onset of vehicle AEB (m/s)
Pre Braking Average Vehicle Speed	Measured average speed of the vehicle prior to AEB. (mph)
Impact Speed	Measured speed of the vehicle at longitudinal range = 0 (mph)
Speed Reduction	Difference between "***Pre Braking Speed Average***" and "***Impact Speed***" (mph)
Percent Speed Reduction of AEB	Percent of speed reduced compared to pre brake speed at onset of vehicle AEB (%)
Average AEB Braking	Average braking level of vehicle AEB from onset of vehicle AEB to longitudinal range = 0 (m/s^2)
Vehicle Final Rest Range	Minimum longitudinal range at the end of test conduct (meters)

3.2.4 System Performance Results

The analysis of system performance data focused on the measures used as input to the PCAM safety benefits estimation method. The test data were used to superimpose a PCAM system onto a historical vehicle-pedestrian crash reconstruction. The test data were correlated to the crash data using the described variations of test conditions. Not all test conditions could be correlated to a crash, such as pedestrian clothing, pedestrian direction, and detailed impact location. However, the following conditions were correlated to the crash data:

- <u>Pedestrian Motion</u>: Pedestrian action from the crash data was used to determine pedestrian motion. Pedestrian motions are based on the pedestrian mannequin motions from the objective tests.
    - Motion that was described as actively "crossing the roadway" was considered to be an S1 scenario.
    - Other motions (i.e., adjacent to roadway, disabled vehicle related, in roadway, movement along roadway, movement on sidewalk, waiting to cross roadway, and working in trafficway) were considered to be S4 scenarios.
        - Movement along roadway (with a known direction) and movement on sidewalk were considered to be S4 scenarios where the pedestrian was walking. Other S4 motions were considered to involve a stationary pedestrian.
- <u>Pedestrian Size</u>: Pedestrian age from the crash data was used to determine a general size for the pedestrian [2]. Pedestrian sizes are based on the pedestrian mannequins from the objective tests.
    - Pedestrian age's $\geq$ 13 are considered to be adults.
    - Pedestrian age's < 13 are considered to be children.
- <u>Pedestrian Speed</u>: Pedestrian action from the crash data was used to determine pedestrian speed. Pedestrian speeds are based on the pedestrian mannequin speeds from the objective tests.
    - Jogging/Running is considered a pedestrian running.
    - Non-descript motions (i.e., crossing roadway, movement along roadway, and movement on sidewalk) were considered to be walking.
    - Variables that did not identify movement (i.e., waiting to cross, in roadway, disabled vehicle related, adjacent to roadway, working in trafficway, and entering/exiting vehicle) were considered to be stationary.
- <u>Lighting</u>: Lighting conditions from the crash data were used to determine the environmental lighting conditions. Environmental lighting conditions were tied to the crash data based on availability of any light source.
    - Dark was the only condition to be considered night (or dark)
    - Dark – but lighted, was considered to have enough external light to be considered lighted, or day.
- <u>Obstructions</u>: Driver obstruction from crash data was used to determine if physical obstructions were blocking the driver's view of the pedestrian.
    - Physical obstructions (i.e., motor vehicles, roadway features, trees, crops, or buildings) were considered to be an obstruction.

- Atmospheric, lighting, and internal obstructions (i.e., glare from external light, rain, snow, fog, smoke, broken windshield, inadequate defrost/defog, and inadequate headlights) were not considered in this analysis as how these obstructions interfere with AEB activation could accurately be determined.[34]
    - Only crashes explicitly identified with "no obstruction" were considered to be unobstructed vision.
- Vehicle Travel Speed:[35] Travel speed is rarely noted in the crash data with the majority of cases coded as "unknown" travel speed. However, in instances where travel speed was known, the travel speed was tied to the test data. Crash data for lower speeds (< 10 mph) and higher speeds (> 40 mph) could not be directly tied to the test data; therefore, available test conditions were extended to encompass all the crash data.
    - Crash cases with speeds less than or equal to 10 mph were tied to the 10 mph test data (or lowest test speed conducted).
    - Crash cases with speeds greater than or equal to 40 mph were tied to the 40 mph test data (or highest test speed conducted).
    - Crash cases with available speeds were correlated to the appropriate test speed bin as obtained from the "pre-braking speed average" variable as seen in Table 13.

The resulting correlation led to the identification of the priority six testing setups that were implemented into the simulation, as seen in Table 14. For other scenarios, if empirical test data could not be applied to crash data, system effectiveness was conservatively set to 0. This implies that PCAM systems would not have an immediate benefit. Further research, testing, and analysis would be required to improve this estimate.

[34] These types of obstructions were not tested and cannot be correlated to the crash data. These obstructions may not affect PCAM activation, depending on the specific location of the sensing equipment and the obstruction.
[35] Travel speed may not be the same as impact speed.

Table 14: Priority PCAM Testing Setups That Correlate to Crash Data and Associated Number of Test Runs and No Impact Results*

Scenario	Pedestrian Size	Pedestrian Speed	Lighting	Obstruction	Number of Tests	No Impact Results
S1	Adult	3.1 mph	Day	No	497	397
S1	Adult	4.9 mph	Day	No	265	90
S1	Child	3.1 mph	Day	No	194	167
S1	Child	3.1 mph	Day	Yes	108	42
S4	Adult	Stationary	Day	No	403	325
S4	Adult	3.1 mph Away	Day	No	202	183

*Results are shown for all tested vehicle speeds, from 10 mph to 40 mph. Variations in results across test setups can be attributed to changes in testing conditions.

Figure 7 shows the relationship between vehicle travel speed and warning time for all three OEMs in an S1 with an adult walking during the day without any obstruction. Results show that warnings are appropriately issued up to maximum test speeds for the respective vehicles. All three vehicles issued warnings less than 2 s TTC, with crashes tending to occur when a warning was issued under 1 s TTC. However, because no driver braking was applied, the results of whether a crash was avoided or not cannot be attributed to warning time, but can be speculated that the system picked up the pedestrian later than expected, issuing the warning later and potentially delaying any subsequent AEB activation. Figures below are sample plots for a specific testing configuration. For this testing condition, OEM 3 speed was limited to ensure the safety of the testing equipment (more impacts at higher speeds create more chance for equipment braking). A full list of test results by test conditions listed in Table 14 can be seen in Appendix D.

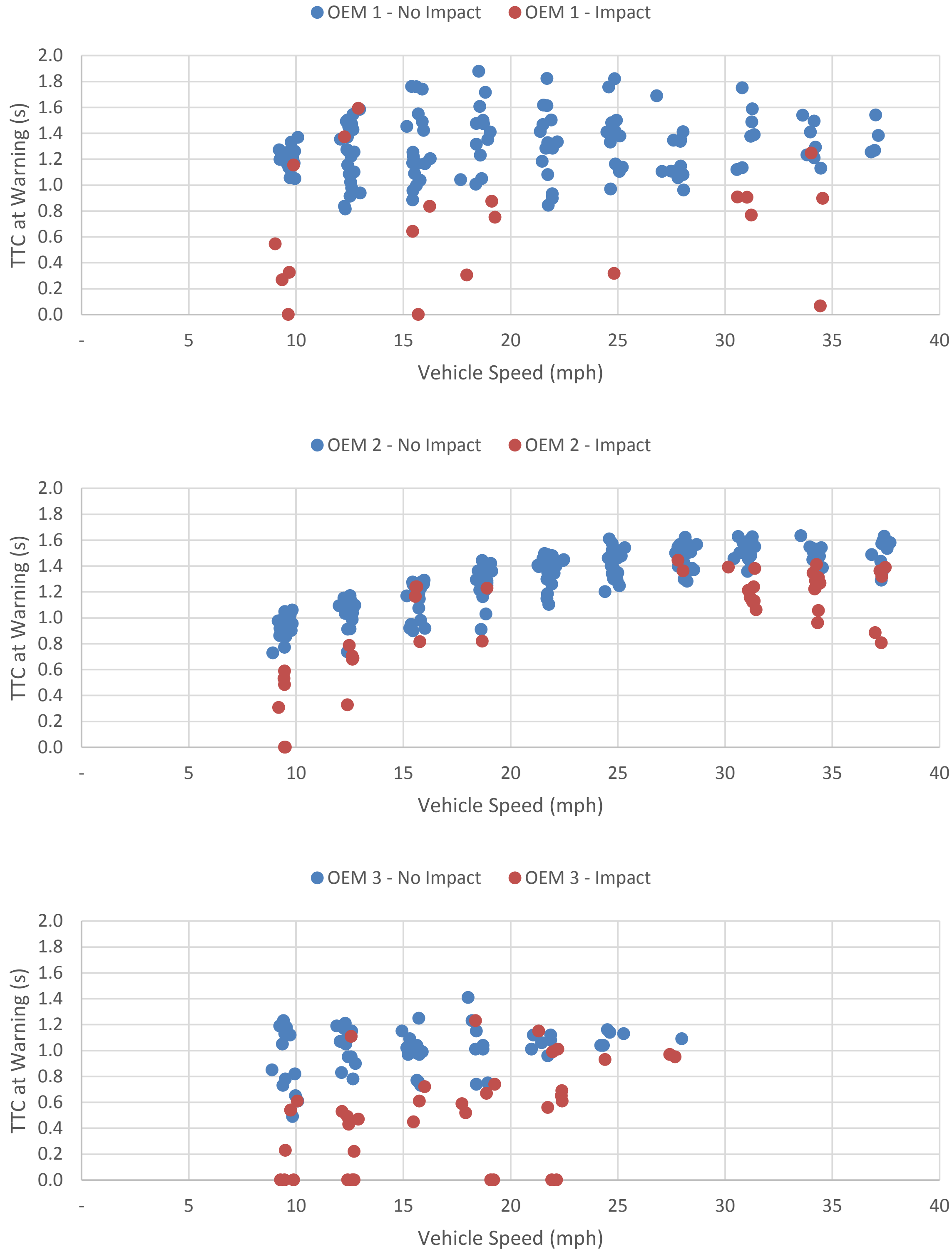

Figure 7: Test Results With Only AEB Active, Comparing TTC at Warning for an Adult Walking in S1 During the Day With No Obstruction for All OEMs

Figure 8 shows the relationship between the vehicle speed and the activation time for AEB in an S1 with an adult walking during the day without any obstruction. (See Appendix D for a full list of tabulated results). Data show that as the vehicle's travel speed increases, AEB tends to activate earlier and accounts for the majority of successful avoidance activations. However, some successful activations occur with smaller TTC values; these instances may have higher average braking levels or may slow the vehicle enough to allow the pedestrian to finish crossing prior to reaching the impact location.

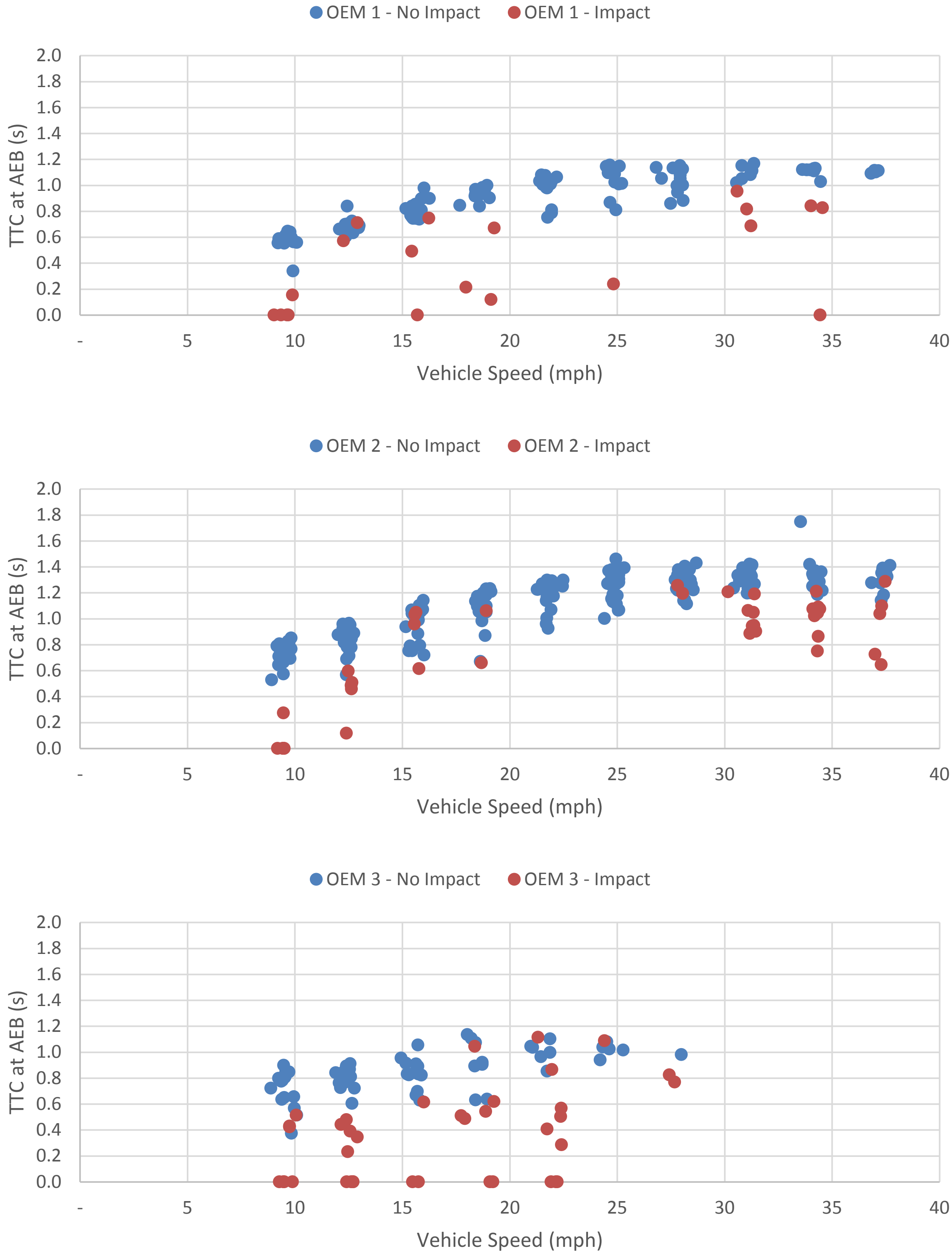

Figure 8: Test Results With Only AEB Active, Comparing AEB Activation Time for an Adult Walking in S1 During the Day With No Obstruction for All OEMs

Figure 9 shows the relationship between vehicle travel speed and vehicle performance in terms of speed reduction for an S1 with an adult walking during the day without any obstruction. (See Appendix D for a full list of tabulated results). This relationship indicates whether algorithms are tailored for crash mitigation at lower speeds. The charts show good collision avoidance performance up to the maximum testing conditions; however, even at lower speeds, impacts did occur. Some OEMs specified that their PCAM systems were only optimized for crash avoidance up to a specific speed, lower than the maximum tested. These charts can illustrate operational capabilities of PCAM systems, as two OEMs have effective collision avoidance within specific speeds.

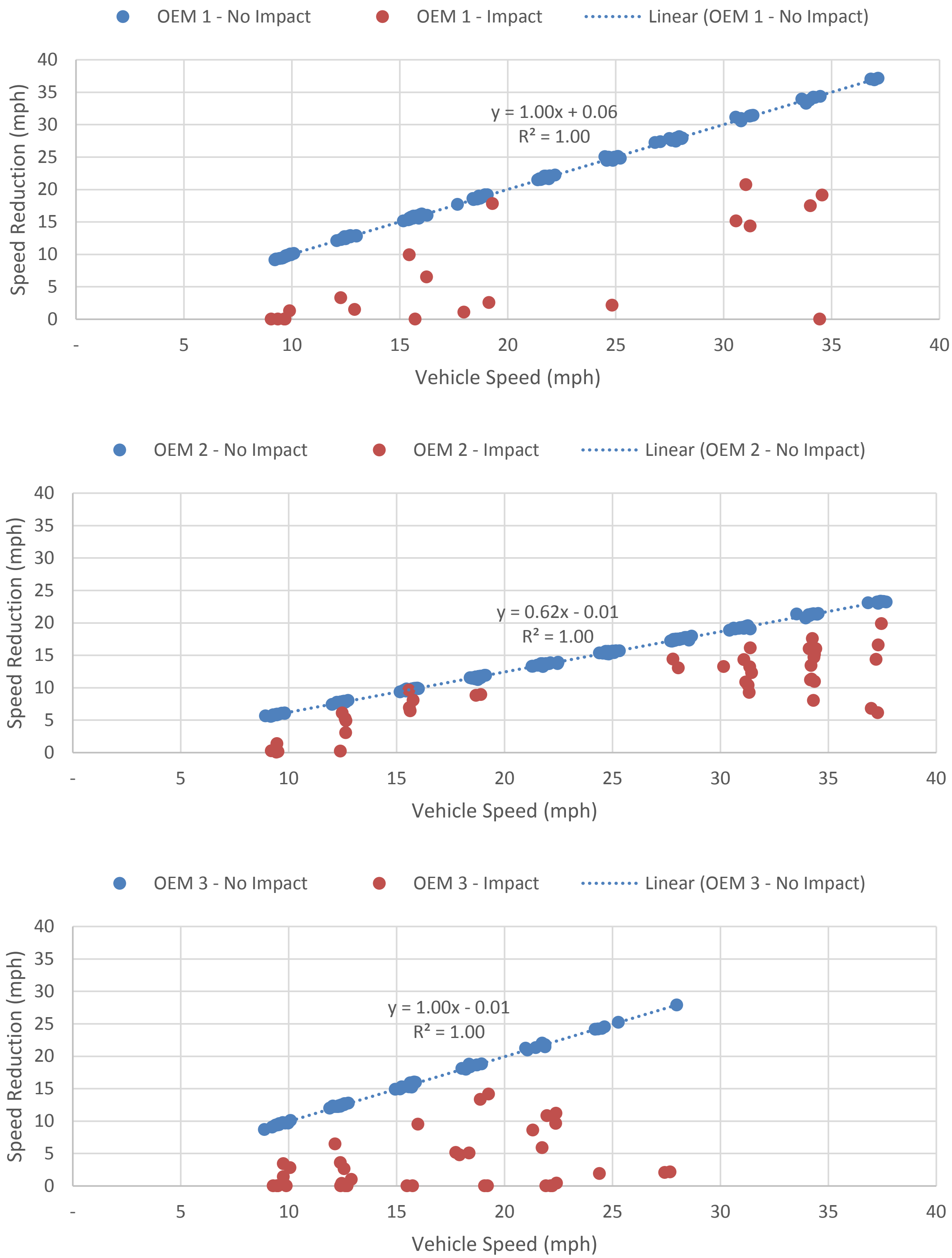

Figure 9: Test Results With Only AEB Active, Comparing Speed Reduction for an Adult Walking in S1 During the Day With No Obstruction for All Three OEMs

Figure 10 illustrates system performance of PCAM systems based on the relationship between vehicle speed and AEB level for an S1 with an adult walking during the day without any obstruction. (See Appendix D for a full list of tabulated results). This relationship indicates whether vehicle speed is used to offer softer braking (i.e., better comfort) or later activation (i.e., less nuisance activations). The data shows that PCAM systems have a very slight relationship between travel speed and braking level. More testing, including lower and higher test speeds could strengthen this observation. Instances where lower braking levels were used, typically resulted in a crash; however, instances occur where higher braking still results in a crash and may be due to later activation than expected. All OEMs seemed to aim for 0.4 g or higher braking, independent of vehicle speed.

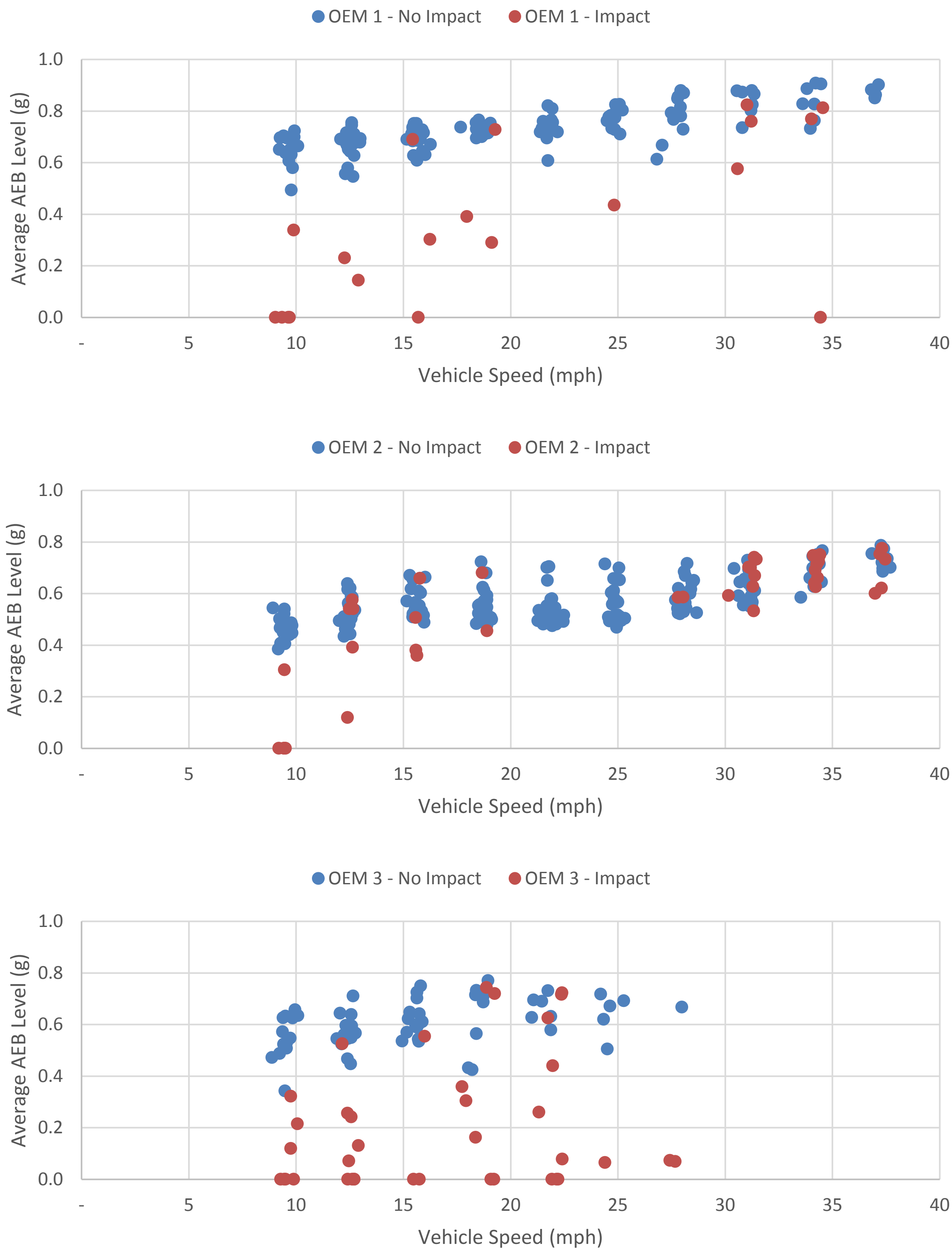

Figure 10: Test Results With Only AEB Active, Comparing Average AEB Level for an Adult Walking in S1 During the Day With No Obstruction for All Three OEMs

Figure 11 evaluates system performance of PCAM systems based on the relationship between AEB activation (in terms of TTC) and AEB level for an S1 with an adult walking during the day without any obstruction. (See Appendix D for a full list of tabulated results). This relationship indicates whether earlier activation times require less braking or if later activation times require more braking. The data show that PCAM systems target a specified braking level, regardless of activation timing. The charts show that many of the no impact results are associated with high braking levels (no impact average AEB level of 0.73, 0.57, and 0.6 g for OEM 1, OEM 2, and OEM 3 respectively), however there are some instances where an impact occurred even with high braking. These impacts could be caused by a delay AEB activation. Further, there are instances with lower AEB levels, these instances AEB activation occurred later and were not able to reach full braking potential and resulted in crashes.

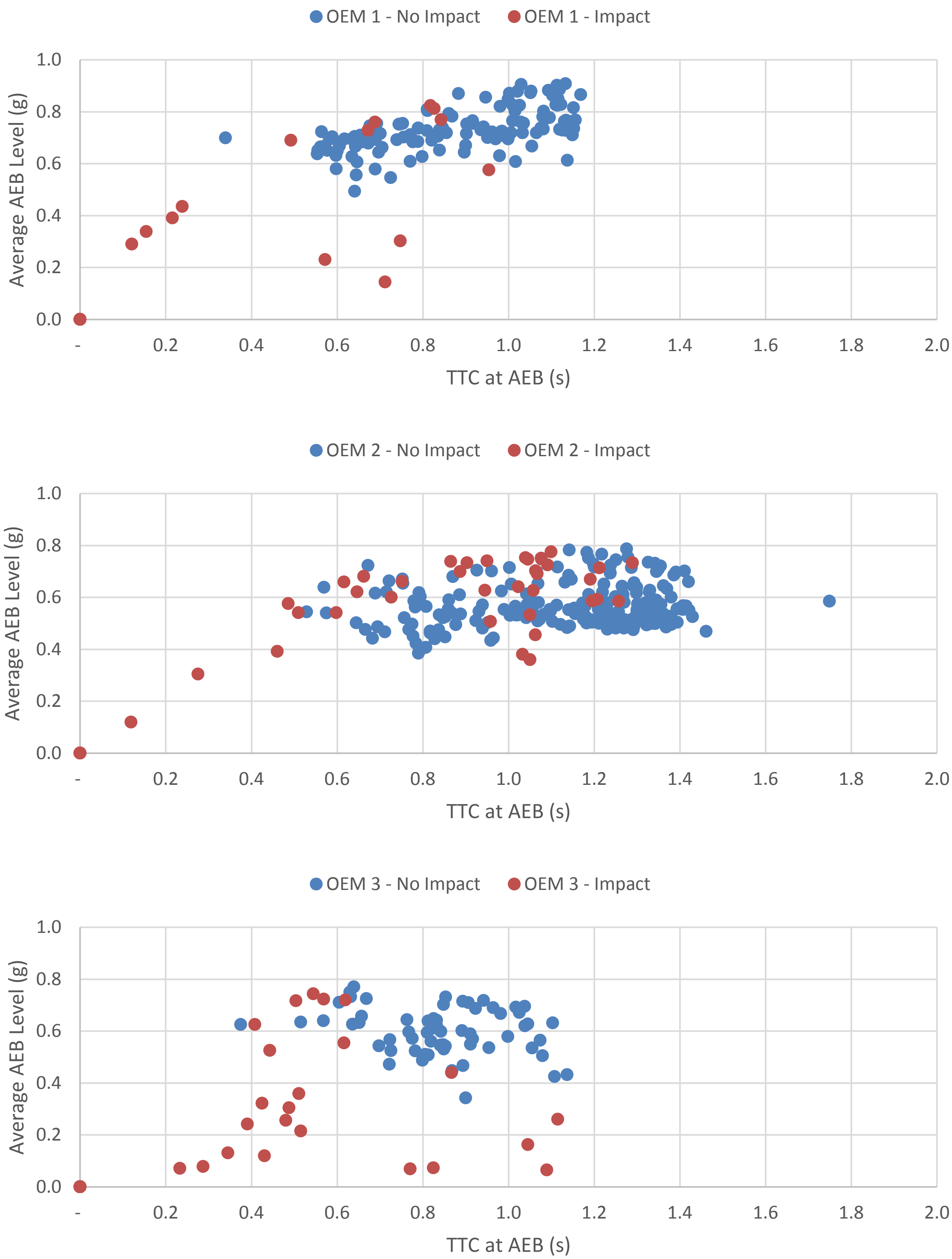

Figure 11: Test Results With Only AEB Active, Comparing AEB Activation Time From OEM 2 for an Adult Walking in S1 During the Day With No Obstruction

Finally, Figure 12 investigates the relationship between travel speed and the time difference between warning and AEB activation for an S1 with an adult walking during the day without any obstruction. (See Appendix D for a full list of tabulated results). This relationship shows the potential time frame where a driver may initiate braking, prior to AEB. The figures show that for two OEM systems, the warning was issued less than 0.4 s prior to AEB activation. On average, OEM 1 provided the driver with 0.42 s between warning and AEB activation. OEM 2 and OEM 3 had significantly smaller windows at 0.19 s and 0.17 s respectively. This time frame, is significantly lower than the average human reaction time as noted later in Section 3.3. These OEM systems may only see marginal improvements in effectiveness with a warning as compared to with AEB only.

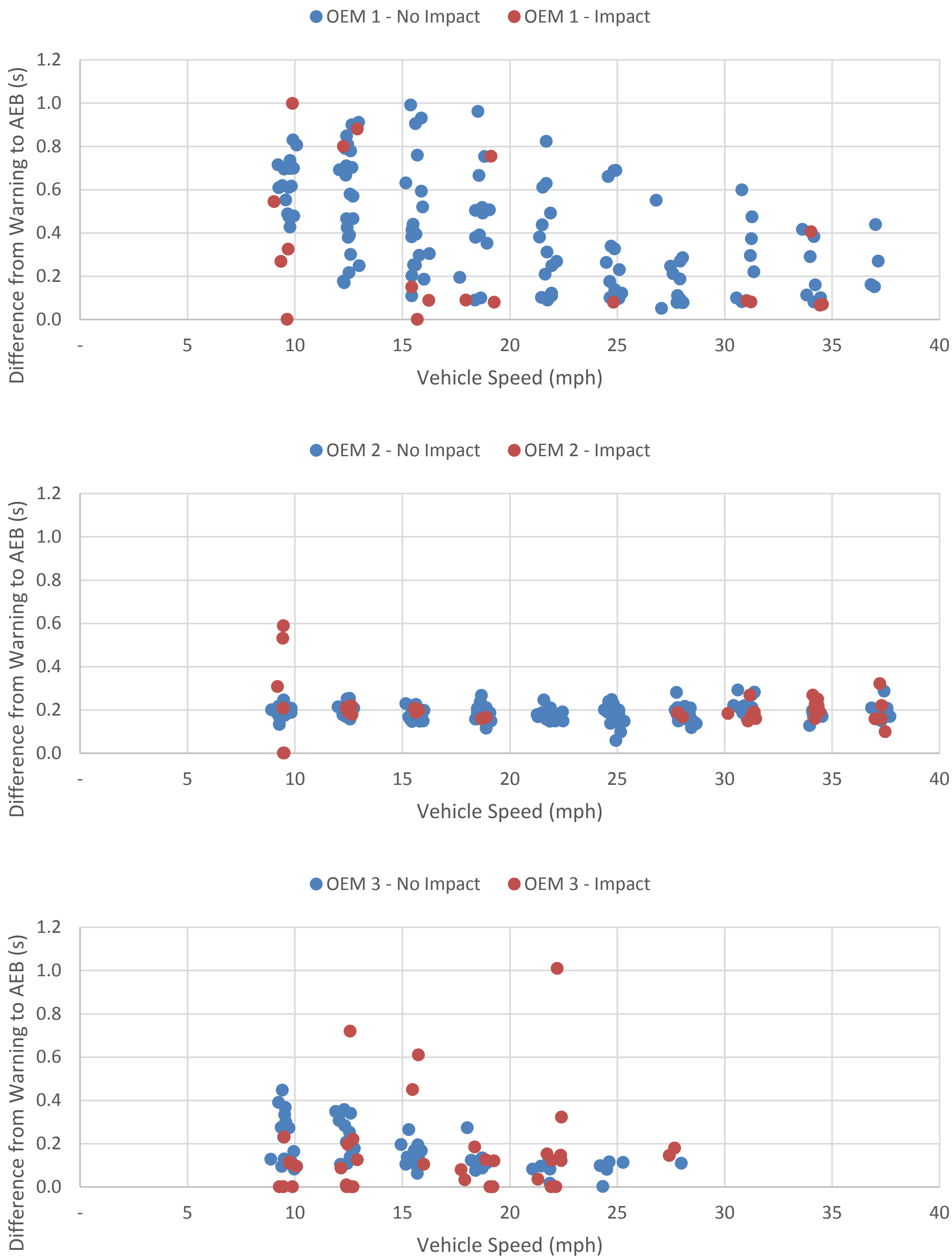

Figure 12: Test Results With Only AEB Active, Comparing Difference From Warning Time to AEB Activation for an Adult Walking in S1 During the Day With No Obstruction for All OEMs

3.2.5 Input into the Simulation

Track test data were superimposed onto the historical crash data using the available test conditions to estimate the crash probability with system intervention. Tests were correlated with GES and FARS cases that shared similar kinematics and conditions. Data points from applicable test runs were pulled, maintaining the vehicle speed, pedestrian, speed, warning time, AEB activation time, and AEB level relationship, then run through the Monte Carlo crash reconstruction simulation.[36] Appendix D provides the complete tabulated test data results used as input into the simulation.

3.3 Driver Performance Data

Previous research studies were leveraged to identify driver responses in conflicts with the presence of a warning. Driver performance was incorporated into the treatment data to determine additional benefits when a warning is issued in addition to AEB. As seen in Table 15, driver reaction time was estimated as a lognormal distribution with a mean of 1.1 s and standard deviation of 0.3 [18]. Also in Table 15, driver braking level was estimated as a normal distribution curve with a mean of 0.5 g and a standard deviation of 0.1 [19].

Table 15: Driver Performance Measures in Response to a PCAM Warning

Inputs:	Min	Max	Mean*	Std. Dev.*	Distribution Type
Host Driver Reaction Time In Control (s)	0	5	1.1	0.3	Log Normal
Host Driver Deceleration In Control (g)	0.25	0.75	0.5	0.1	Normal

*Mean and standard deviation are based on sample data not population

3.4 Input Data Summary

Table 16 shows the full list of potential input sources and their use in the safety benefits estimation methodology.

Table 16: Data Sources and their Input into Safety Benefits

<table>
<tr><th>Data Source</th><th colspan="2">Input</th><th>Notes</th></tr>
<tr><td rowspan="5">Crash databases (GES, FARS)</td><td>N_C</td><td>Target crashes</td><td rowspan="5">Baseline crashes
Crashes for reconstruction</td></tr>
<tr><td>N_I</td><td>Target Injured</td></tr>
<tr><td>CP_{Base}</td><td>Crash probability (Baseline)</td></tr>
<tr><td>o_{Base} (i)</td><td>Crash speed distribution (Baseline)</td></tr>
<tr><td>h_m (i)</td><td>Injury probability Curve</td></tr>
<tr><td rowspan="2">Track tests and Literature</td><td>CP_{PCAM}</td><td>Crash probability (PCAM)</td><td rowspan="2">Driver Performance with PCAM Warning
AEB activation timing, AEB level</td></tr>
<tr><td>o_{PCAM} (i)</td><td>Crash speed distribution (PCAM)</td></tr>
</table>

[36] A single test run included vehicle speed, warning time, AEB activation time, average AEB level, and pedestrian speed. The variables were pulled dependent on the test run to avoid extreme instances and to represent the test data as accurately as possible (e.g., early activation when a pedestrian is obstructed and late activation for an unobstructed pedestrian are instances that should not occur)

4 RESULTS

The focus of this analysis is on target S1 and S4 vehicle-pedestrian crashes. As previously defined and detailed in Section 3.1.1, these two scenarios account for:

- 10,431 crashes of all severities, comprising about 49% of all PCAM-addressable crashes or about 14% of all vehicle-pedestrian crashes.
- 2,016 fatal crashes, comprising about 92 percent of all fatal PCAM-addressable crashes or about 44 percent of all fatal vehicle-pedestrian crashes.
- 3,889 MAIS 2^+ injured pedestrians, comprising about 72 percent of all injured pedestrians in PCAM-addressable crashes or about 23 percent of injured pedestrians from all vehicle-pedestrian crashes.
- 2,739 MAIS 3^+ injured pedestrians, comprising about 83 of all injured pedestrians in PCAM-addressable crashes or about 30 percent of injured pedestrians from all vehicle-pedestrian crashes.
- $20,297,000,000 in comprehensive costs, comprising about 87 percent of all PCAM-addressable crashes or about 37 percent of all vehicle-pedestrian crashes (S1 accounts for $14,071,500,000 while S4 accounts for $6,225,700,000).

4.1 S1 – Vehicle Going Straight and Pedestrian Crossing

These crashes can occur under various conditions, as depicted in previous research [5]. However, to accurately assess system effectiveness $\boldsymbol{E_A}$ and $\boldsymbol{E_M}$ from Equations **(1)** and **(5)**, a detailed connection was made between the baseline crashes, objective test data, and input into the simulation.

4.1.1 S1 Target Crash Population

Table 17 shows detailed crash statistics for PCAM-addressable S1 crashes. For all PCAM-addressable S1 crashes, approximately 76 percent of GES crashes and 63 percent of FARS crashes contained sufficient and correlating data. Included within the table is an estimate of the comprehensive costs that include lost productivity, medical costs, legal and court costs, emergency service costs, insurance administration costs, travel delay, property damage, and workplace losses. Such costs were estimated using data provided from the most recent detailing the economical and societal costs of motor vehicle crashes [20]. The costs incorporate both GES and FARS data and account for 64 percent of PCAM-applicable S1 crashes.[37] Further information on cost calculations can be found in Appendix A. The remaining proportion of S1 crashes did not have sufficient crash data or data that correlated to applicable objective test results. Thus, this analysis assumed very conservatively that PCAM systems have no safety benefits in those remaining S1 crashes.[38]

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[37] When estimating costs, the number of fatalities of FARS is substituted into the GES for the estimated fatalities, or 'K''s within the injury severity variable.

[38] Although PCAM systems may work in other conditions, for example low light or night time conditions, there was insufficient system performance information to predict the potential effectiveness of a PCAM system in these conditions therefore it is estimated that there is no change.

Table 18 shows detailed injury information for the crashes mentioned. These S1 crashes represent 66 percent of MAIS 2^+ and 64 percent of MAIS 3^+ injured pedestrians. Again, this table introduces the costs associated with these crashes. When estimating costs for injury, the costs account for only pedestrians injured MAIS 2^+ or MAIS 3^+.

Table 17: Two-Year Annual Average Number (2011 to 2012) of S1 Target Crashes

PCAM Scenario	Pedestrian Size	Pedestrian Speed	Obstruction?	Lighting	GES Crashes	FARS Crashes	Costs (Million $)
S1	Adult	Walk	No	Day	4,582	838	$ 8,393
S1	Adult	Run	No	Day	-	1	$ 5
S1	Child	Walk	No	Day	796	35	$ 433
S1	Child	Walk	Yes	Day	279	9	$ 124
Percent of PCAM-Addressable S1					**76%**	**63%**	**64%**

Table 18: Two-Year Annual Average Number (2011 to 2012) of Injured Pedestrians in S1 Target Crashes

PCAM Scenario	Pedestrian Size	Pedestrian Speed	Obstruction?	Lighting	MAIS 2+		MAIS 3+	
					Pedestrians Injured	Costs (Million $)	Pedestrians Injured	Costs (Million $)
S1	Adult	Walk	No	Day	1,576	$ 8,269	1,111	$ 8,083
S1	Adult	Run	No	Day	1	$ 5	1	$ 5
S1	Adult	Walk	No	Day	150	$ 408	72	$ 377
S1	Child	Walk	Yes	Day	52	$ 115	24	$ 104
Percent of PCAM-Addressable S1					**66%**	**63%**	**64%**	**63%**

Breaking down the crashes in Table 17, only a percentage of these crashes contained enough information to be reconstructed (i.e., travel speed information). The number of applicable GES cases and their representative annual weight and the number of applicable FARS cases are summarized in Table 19. It is important to note, that although only one FARS case was identified for an adult pedestrian running across the roadway in the day, crash avoidance effectiveness can still be determined using the methodology presented in this report.[39]

Table 19: Number of Total S1 Crashes With Available Information for Detailed Crash Reconstruction from 2011 and 2012 Crash Data*

PCAM Scenario	Pedestrian Size	Pedestrian Speed	Obstruction?	Lighting	GES		# FARS Cases
					# Cases	Sum of Weights	
S1	Adult	Walk	No	Day	116	2,451	741
S1	Adult	Run	No	Day	0	0	1
S1	Child	Walk	No	Day	19	511	37
S1	Child	Walk	Yes	Day	6	89	11

*These values are total values across two years, as opposed to annual averages

[39] This methodology uses a Monte Carlo simulation. This single case was reconstructed 100,000 times and results were obtained in terms of crashes and impact speed distributions for treatment conditions.

Of the available cases for reconstruction, travel speed information was used to correlate the harm sustained to the pedestrian in the baseline crashes. Table 20 shows a sample distribution of vehicle travel speed information for an adult walking across the roadway during the day with no obstruction. This information helps to determine the baseline harm sustained to the pedestrian as seen in Equation (7).

Table 20: Travel Speed Distribution of Actual GES and FARS Crash Data for an Adult Walking in S1 During the Day With No Obstruction

Speed Bin (mph)		GES	FARS
1	**0 < x ≤ 5**	10.9%	0.5%
2	**5 < x ≤ 10**	5.5%	0.1%
3	**10 < x ≤ 15**	14.6%	0.7%
4	**15 < x ≤ 20**	18.9%	1.9%
5	**20 < x ≤ 25**	8.3%	3.0%
6	**25 < x ≤ 30**	10.4%	11.5%
7	**30 < x ≤ 35**	7.8%	20.4%
8	**35 < x ≤ 40**	11.0%	19.6%
9	**40 < x ≤ 45**	7.5%	19.7%
10	**45 < x ≤ 50**	3.8%	6.9%
11	**50 < x ≤ 55**	1.0%	4.0%
12	**55 < x ≤ 60**	0.0%	2.6%
13	**60 < x ≤ 65**	0.4%	3.2%
14	**65 < x ≤ 70**	0.0%	0.8%
15	**70 < x ≤ 75**	0.0%	0.4%
16	**75 < x**	0.0%	4.7%

A regression model was used to determine the function for the various baseline travel speed curves for S1 crashes. Equation **(**10**)** was used as the baseline equation to determine the functions.

$$\boldsymbol{f(i)} = \frac{\boldsymbol{e}^{-\frac{(\boldsymbol{i}-\boldsymbol{\mu})^2}{2\boldsymbol{\sigma}^2}}}{\sqrt{2\boldsymbol{\pi}}\boldsymbol{\sigma}} \qquad \textbf{(10)}$$

Where:
$\boldsymbol{i}$ ≡ Ordinal number of the impact speed bin
$\boldsymbol{\mu}$ ≡ Population mean of distribution
$\boldsymbol{\sigma}$ ≡ Population standard deviation of distribution

Smoothed curves were developed for all the baseline S1 crash conditions from Table 19. Sample results from the regression model are shown in Table 21 with the two curves (actual data and smoothed function) plotted in Figure 13 and Figure 14 for GES and FARS databases, respectively. The full list of results and plots is provided in Appendix E for all S1 baseline conditions. These results are used to determine the baseline harm sustained to the pedestrian, as seen in Equation (7).

Table 21: Observed Statistics for Normal Distribution Function of Baseline Crash Data for an Adult Walking in S1 During the Day With No Obstruction

Variable		GES	FARS
Mean	μ	2.65	7.73
Standard Deviation	σ	1.02	2.42

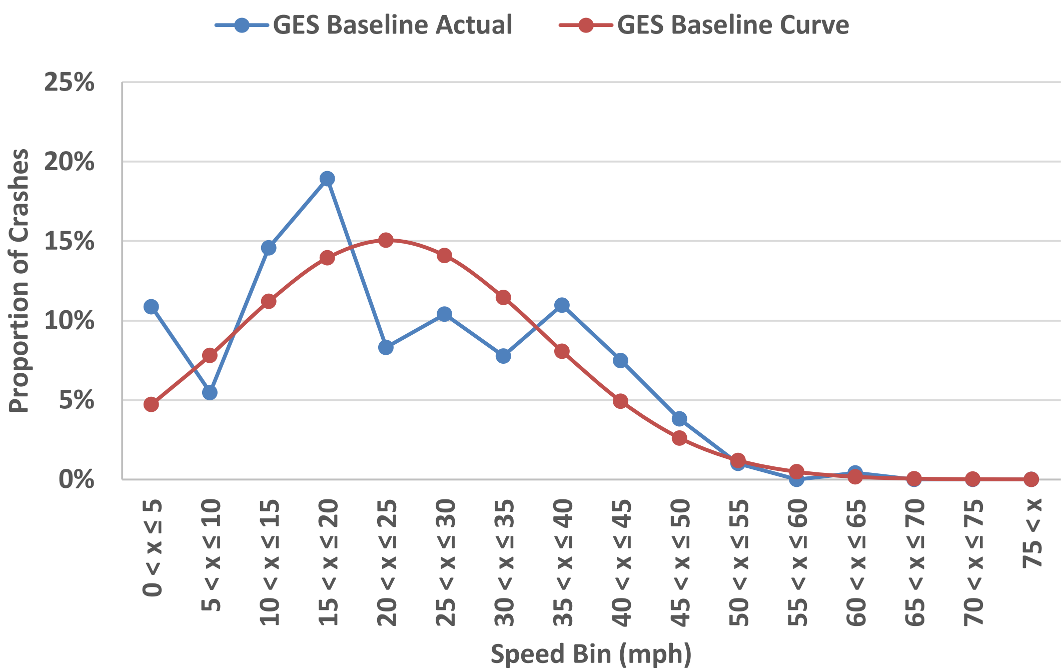

Figure 13: Plots of Normal Distribution Function Compared to Actual GES Data for an Adult Walking in S1 During the Day With No Obstruction

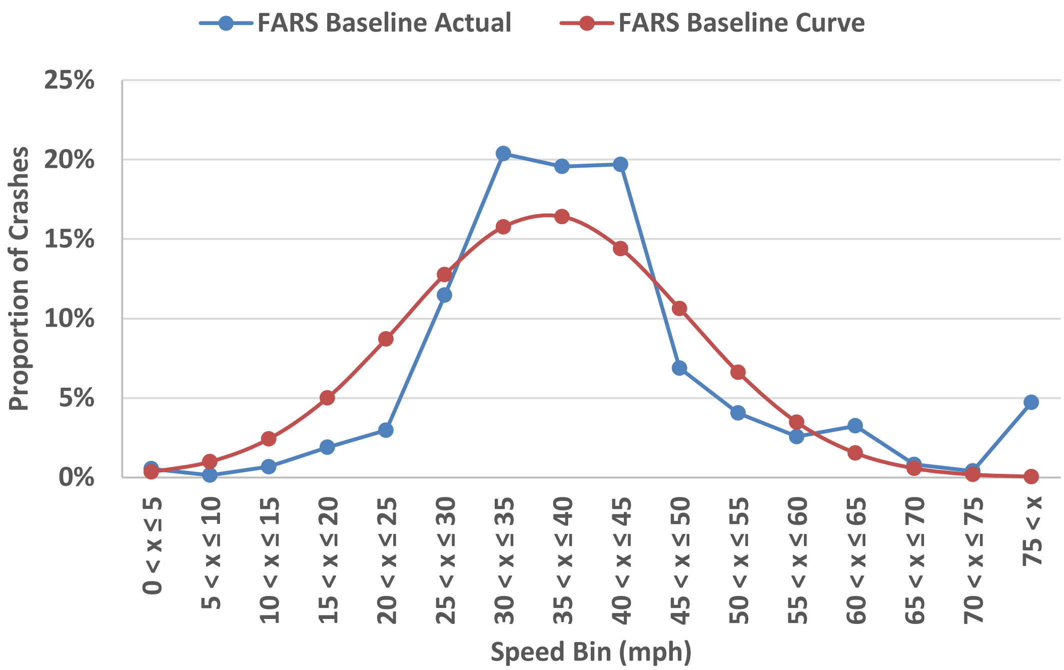

Figure 14: Plots of Normal Distribution Function Compared to Actual FARS Data for an Adult Walking in S1 During the Day With No Obstruction

4.1.2 PCAM Crash Avoidance Effectiveness in S1

The method to estimate PCAM crash avoidance effectiveness in S1 target crashes superimposed performance test results from three production systems onto reconstructed crashes from GES and FARS using computer simulation. Furthermore, each production system was simulated under three variations of the PCAM system (i.e., AEB only, first braking response, and best braking response). Table 22 shows the results from the simulation for the various S1 configurations. These results represent E_A in Equation **(4)**.

Results show that the system is very effective without an obstruction, regardless of pedestrian size. In addition, no OEM was the most effective on all four conditions. Finally, considering the minimal amount of time between warning and AEB activation, the difference in system logic yielded marginal improvements.

Table 22: Crash Avoidance Effectiveness of PCAM Systems in S1

PCAM Scenario	Pedestrian Size	Pedestrian Speed	Obstruction?	Lighting	System Logic	GES			FARS		
						OEM 1	OEM 2	OEM 3	OEM 1	OEM 2	OEM 3
S1	Adult	Walk	No	Day	AEB	76%	75%	40%	52%	49%	7%
					First	76%	75%	40%	52%	49%	7%
					Best	77%	75%	40%	52%	49%	7%
S1	Adult	Run	No	Day	AEB	N/A*	N/A*	N/A*	10%	68%	0%
					First	N/A*	N/A*	N/A*	10%	68%	0%
					Best	N/A*	N/A*	N/A*	10%	68%	0%
S1	Child	Walk	No	Day	AEB	90%	70%	64%	37%	36%	12%
					First	89%	70%	64%	36%	36%	12%
					Best	90%	71%	64%	37%	36%	12%
S1	Child	Walk	Yes	Day	AEB	20%	22%	39%	0%	0%	9%
					First	20%	21%	38%	0%	0%	9%
					Best	20%	22%	39%	0%	0%	9%

*No GES crashes met conditions to be reconstructed

4.1.3 PCAM Crash Mitigation Effectiveness in S1

PCAM systems may mitigate injury to the pedestrian if a crash is not avoided, by reducing the vehicle's travel speed through earlier driver response and/or AEB activation. Sample results are shown in Table 23 for OEM 1, showing the resulting distribution of impact speeds given a crash with an adult walking across the roadway in the day with no obstruction, under the AEB only treatment condition. These results are curve fitted through a regression model and used to determine harm sustained to the pedestrian with PCAM intervention in Equation (8).

Table 23: Impact Speed Distribution of OEM 1 Treatment Results from Simulation for an Adult Walking in S1 During the Day With No Obstruction, using AEB Only

Speed Bin (mph)		GES	FARS
1	0 < x ≤ 5	36.3%	23.4%
2	5 < x ≤ 10	55.3%	41.9%
3	10 < x ≤ 15	5.0%	13.8%
4	15 < x ≤ 20	3.4%	10.1%
5	20 < x ≤ 25	0.0%	0.8%
6	25 < x ≤ 30	0.0%	0.8%
7	30 < x ≤ 35	0.0%	9.0%
8	35 < x ≤ 40	0.0%	0.0%
9	40 < x ≤ 45	0.0%	0.0%
10	45 < x ≤ 50	0.0%	0.0%
11	50 < x ≤ 55	0.0%	0.0%
12	55 < x ≤ 60	0.0%	0.0%
13	60 < x ≤ 65	0.0%	0.0%
14	65 < x ≤ 70	0.0%	0.0%
15	70 < x ≤ 75	0.0%	0.0%
16	75 < x	0.0%	0.0%

A regression model was used to determine the function for the various treatment impact speed curves for the S1 crashes. Equation **(**11**)** represents these curves.

$$\boldsymbol{f(i)} = \frac{\boldsymbol{e}^{-\frac{(\boldsymbol{log(i)-\mu})^2}{2\sigma^2}}}{\sqrt{2\pi}\boldsymbol{\sigma i}} \tag{11}$$

Where:

$\boldsymbol{i}$ ≡ Ordinal number of the impact speed bin
$\boldsymbol{\mu}$ ≡ Population mean of distribution
$\boldsymbol{\sigma}$ ≡ Population standard deviation of distribution

Smoothed curves were developed for all the treatment S1 crash conditions, including the sample results shown earlier in Table 23. Regression model results for a single simulation (OEM 1 using AEB only) are shown in Table 24 with the two curves (actual data and smoothed function for the two databases) plotted in Figure 15 and Figure 16. The full list of simulation and regression results can be seen in Appendix F. These results are $\boldsymbol{o_{PCAM}}(\mathbf{i})$, used to determine the treatment harm sustained to the pedestrian as seen in Equation (8).

Table 24: Observed Statistics for Log Normal Distribution Function of Baseline Crash Data for an Adult Walking in S1 During the Day With No Obstruction, Under the AEB Only Treatment

	Variable		GES	FARS
AEB Only	Vehicle		OEM 1	OEM 1
	Mean	µ	0.86	0.73
	Standard Deviation	σ	0.33	0.47

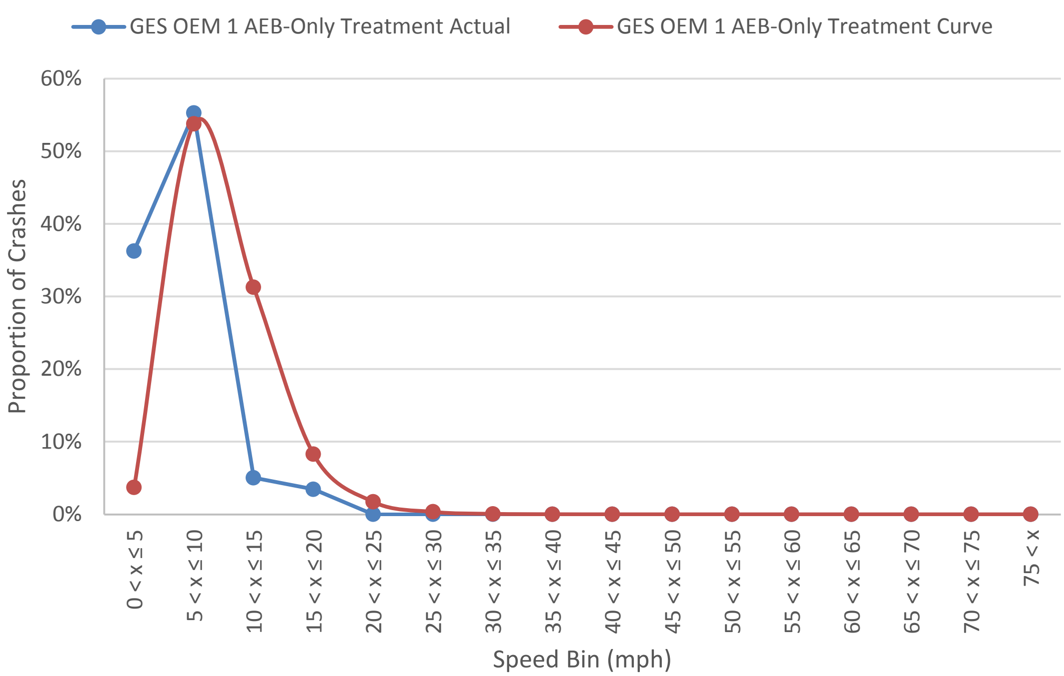

Figure 15: Plots of Log Normal Distribution Function Compared to Actual GES Data for an Adult Walking in S1 During the Day With No Obstruction for OEM 1, Under the AEB Only Treatment

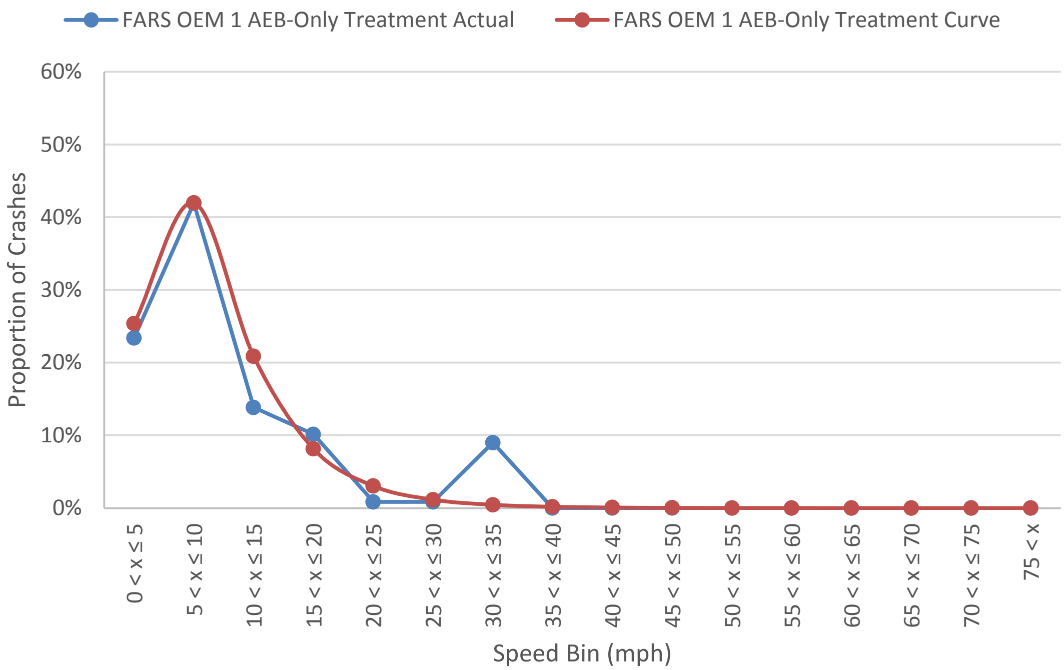

Figure 16: Plots of Log Normal Distribution Function Compared to Actual FARS Data for an Adult Walking in S1 During the Day With No Obstruction for OEM 1, Under the AEB Only Treatment

Figure 17 and Figure 18 illustrate the curve-fit results of the distribution of crashes by impact speed for GES and FARS cases, respectively. The figures contain results without (baseline) and with intervention (all treatments, including AEB only, first braking, and best braking) by database for OEM 1. It can be seen that the warning provided minimal improvement beyond AEB in terms of crash mitigation. That is, the various logic conditions did not provide significantly lower impact speeds, when a crash occurred. Information on the probability of a crash outcome is also included. These results are used as input into Equation (7) and (8), then into Equation **(**6), and later into Equation **(**5) to estimate the PCAM crash mitigation effectiveness in S1 crashes. Appendix G lists the complete results.

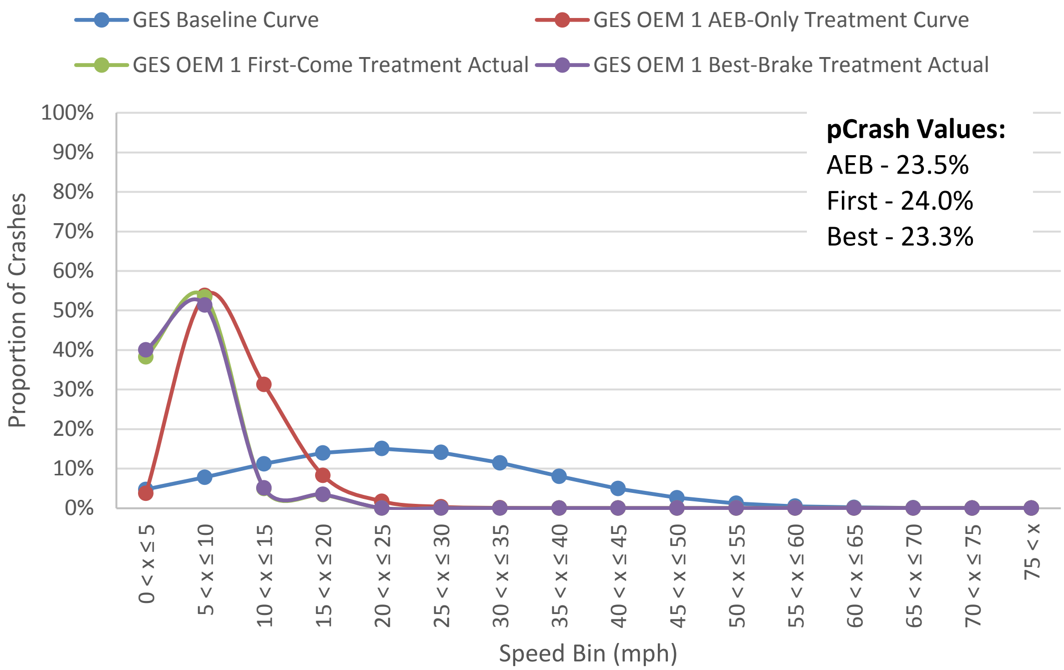

Figure 17: Plots of Functions Comparing GES Baseline to GES Treatment Results Data for an Adult Walking in S1 During the Day With No Obstruction

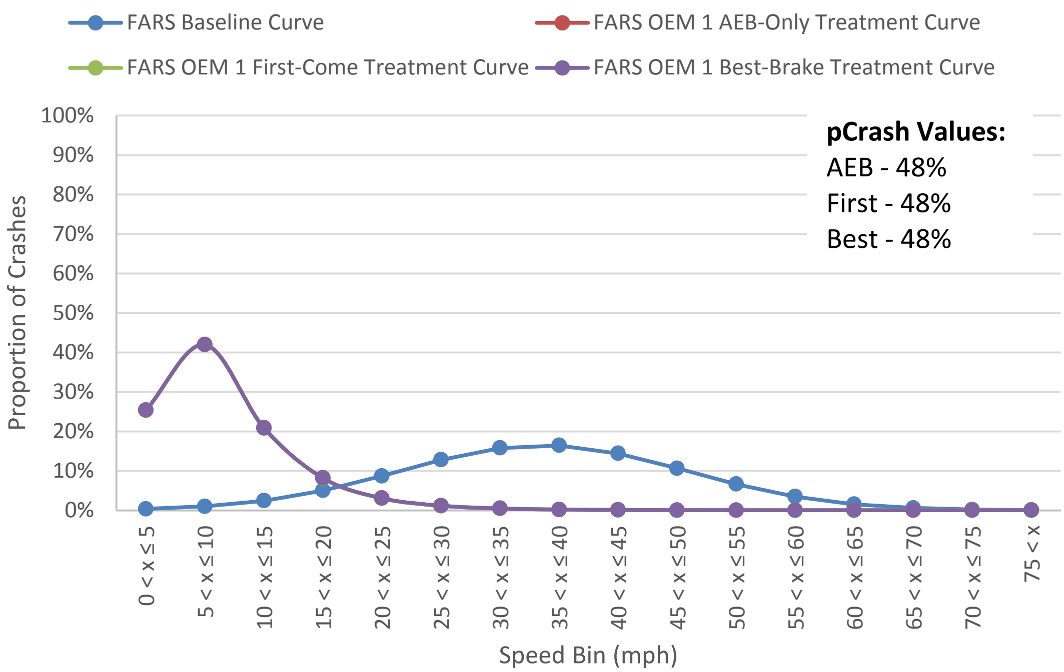

Figure 18: Plots of Functions Comparing FARS Baseline to FARS Treatment Results Data for an Adult Walking in S1 During the Day With No Obstruction

Table 25 shows the results for harm reduction, based on Equation **(6)**. These results are the effectiveness in reducing the harm ratio, independent of crash avoidance. Again, it can be seen that the warning provided minimal results beyond AEB. Red-highlighted cells indicate that the treatment condition mathematically provided more harm than the baseline condition (Equation **(6)**). However, this is due to the curve fitting process. The baseline curves created heavily skewed distributions resulting in poorer curve fits.[40] The resulting curves created this anomaly. Full detailed curve fits can be seen in Appendix F.

Table 26 shows the results of crash mitigation effectiveness, based on Equation **(5)**. These results incorporate harm reduction and crash avoidance effectiveness. Data show that all OEM systems performed significantly better without an obstruction. Furthermore, each OEM system excelled under different conditions and provided minimal improvement beyond AEB.

[40] The poor curve fit was identified in the GES baseline curve fitting process. All three OEM systems were affected by this; however, OEM 2 was significantly better in crash avoidance, resulting in almost no crashes (all crashes < 5 MPH). By adjusting these values to remove the curve fitting process, system effectiveness in crash mitigation values could potentially double for OEM 1 and OEM 3 (this would raise the lower limit). OEM 2 can see up to a 6% increase in crash mitigation effectiveness (this would raise the upper limit).

The baseline crash data involved approximately 60 percent of crashes occurring between 5 and 10 MPH. This high peak makes it harder to produce a proper fit and leaves less room for improvement beyond crash avoidance. To improve this issue, more data points could be used in the baseline curve fitting process through more crash data years or more relaxed data constraints on variables.

Table 25: Harm Reduction Ratios of PCAM Systems in S1

	PCAM Scenario	Pedestrian Size	Pedestrian Speed	Obstruction?	Lighting	Harm Measure	GES			FARS		
							OEM 1	OEM 2	OEM 3	OEM 1	OEM 2	OEM 3
AEB Only	S1	Adult	Walk	No	Day	MAIS 2+	0.65	0.66	0.54	0.81	0.76	0.64
						MAIS 3+	0.83	0.83	0.71	0.92	0.88	0.77
	S1	Adult	Run	No	Day	MAIS 2+	N/A*	N/A*	N/A*	0.61	0.62	0.46
						MAIS 3+	N/A*	N/A*	N/A*	0.75	0.75	0.54
	S1	Child	Walk	No	Day	MAIS 2+	-0.05	0.31	-0.52	0.73	0.67	0.60
						MAIS 3+	0.03	0.45	-0.74	0.86	0.80	0.73
	S1	Child	Walk	Yes	Day	MAIS 2+	0.42	0.55	0.55	0.41	0.68	0.70
						MAIS 3+	0.57	0.71	0.71	0.52	0.84	0.86

	PCAM Scenario	Pedestrian Size	Pedestrian Speed	Obstruction?	Lighting	Harm Measure	GES			FARS		
							OEM 1	OEM 2	OEM 3	OEM 1	OEM 2	OEM 3
First Braking	S1	Adult	Walk	No	Day	MAIS 2+	0.66	0.66	0.54	0.81	0.76	0.64
						MAIS 3+	0.83	0.83	0.71	0.92	0.88	0.77
	S1	Adult	Run	No	Day	MAIS 2+	N/A*	N/A*	N/A*	0.61	0.62	0.46
						MAIS 3+	N/A*	N/A*	N/A*	0.75	0.75	0.54
	S1	Child	Walk	No	Day	MAIS 2+	-0.04	0.31	-0.52	0.73	0.67	0.60
						MAIS 3+	0.04	0.45	-0.75	0.86	0.80	0.73
	S1	Child	Walk	Yes	Day	MAIS 2+	0.45	0.55	0.55	0.33	0.69	0.70
						MAIS 3+	0.60	0.71	0.71	0.41	0.85	0.86

	PCAM Scenario	Pedestrian Size	Pedestrian Speed	Obstruction?	Lighting	Harm Measure	GES			FARS		
							OEM 1	OEM 2	OEM 3	OEM 1	OEM 2	OEM 3
Best Braking	S1	Adult	Walk	No	Day	MAIS 2+	0.66	0.66	0.54	0.81	0.76	0.65
						MAIS 3+	0.83	0.83	0.72	0.92	0.88	0.77
	S1	Adult	Run	No	Day	MAIS 2+	N/A*	N/A*	N/A*	0.61	0.62	0.46
						MAIS 3+	N/A*	N/A*	N/A*	0.75	0.75	0.55
	S1	Child	Walk	No	Day	MAIS 2+	-0.05	0.30	-0.52	0.73	0.67	0.60
						MAIS 3+	0.03	0.45	-0.74	0.86	0.80	0.73
	S1	Child	Walk	Yes	Day	MAIS 2+	0.42	0.55	0.55	0.33	0.69	0.70
						MAIS 3+	0.43	0.29	0.29	0.41	0.85	0.86

*No GES crashes met conditions to be reconstructed

Table 26: Crash Mitigation Effectiveness of PCAM Systems in S1

	PCAM Scenario	Pedestrian Size	Pedestrian Speed	Obstruction?	Lighting	Harm Measure	GES			FARS		
							OEM 1	OEM 2	OEM 3	OEM 1	OEM 2	OEM 3
AEB Only	S1	Adult	Walk	No	Day	MAIS 2+	92%	91%	72%	91%	88%	67%
						MAIS 3+	96%	96%	83%	96%	94%	79%
	S1	Adult	Run	No	Day	MAIS 2+	N/A*	N/A*	N/A*	65%	88%	46%
						MAIS 3+	N/A*	N/A*	N/A*	77%	92%	54%
	S1	Child	Walk	No	Day	MAIS 2+	89%	79%	46%	83%	79%	64%
						MAIS 3+	90%	83%	38%	91%	87%	76%
	S1	Child	Walk	Yes	Day	MAIS 2+	54%	65%	73%	41%	68%	73%
						MAIS 3+	65%	77%	82%	52%	84%	87%

	PCAM Scenario	Pedestrian Size	Pedestrian Speed	Obstruction?	Lighting	Harm Measure	GES			FARS		
							OEM 1	OEM 2	OEM 3	OEM 1	OEM 2	OEM 3
First Braking	S1	Adult	Walk	No	Day	MAIS 2+	92%	91%	72%	91%	88%	67%
						MAIS 3+	96%	96%	83%	96%	94%	79%
	S1	Adult	Run	No	Day	MAIS 2+	N/A*	N/A*	N/A*	65%	88%	46%
						MAIS 3+	N/A*	N/A*	N/A*	77%	92%	54%
	S1	Child	Walk	No	Day	MAIS 2+	89%	79%	46%	83%	79%	64%
						MAIS 3+	90%	83%	38%	91%	87%	76%
	S1	Child	Walk	Yes	Day	MAIS 2+	56%	65%	72%	33%	69%	73%
						MAIS 3+	68%	77%	82%	41%	85%	87%

	PCAM Scenario	Pedestrian Size	Pedestrian Speed	Obstruction?	Lighting	Harm Measure	GES			FARS		
							OEM 1	OEM 2	OEM 3	OEM 1	OEM 2	OEM 3
Best Braking	S1	Adult	Walk	No	Day	MAIS 2+	92%	92%	73%	91%	88%	67%
						MAIS 3+	96%	96%	83%	96%	94%	79%
	S1	Adult	Run	No	Day	MAIS 2+	N/A*	N/A*	N/A*	65%	88%	46%
						MAIS 3+	N/A*	N/A*	N/A*	77%	92%	55%
	S1	Child	Walk	No	Day	MAIS 2+	89%	80%	46%	83%	79%	64%
						MAIS 3+	90%	84%	38%	91%	87%	76%
	S1	Child	Walk	Yes	Day	MAIS 2+	54%	65%	72%	33%	69%	73%
						MAIS 3+	65%	77%	82%	41%	85%	87%

*No GES crashes met conditions to be reconstructed

4.1.4 S1 Safety Benefits

Based on the results from this analysis, PCAM systems can potentially avoid between 7 and 77 percent of GES- and FARS- S1 crashes. This estimate is based on performance data from characterization tests of production PCAM systems and limited crash reconstructions for S1. Furthermore, the wide range of system effectiveness values is due to the variations in the three OEM system performance results. Results are compiled and presented as a range to encompass all three OEM systems. Results for the two databases, GES and FARS were also integrated to identify the range of results. For a detailed list of crash avoidance effectiveness broken down by OEM system and database, refer to Table 22.

Table 27 shows the results for crash avoidance effectiveness and the annual number of GES and FARS crashes that could be reduced by a PCAM system. Initial effectiveness results showed minimal differences between PCAM system logic; most likely due to the limited time between warning and AEB activation as noted in Section 3.2.4; for this reason, safety benefit results are only shown for AEB activation. For effectiveness results broken down by system logic, refer to Table 22.

Table 27: PCAM-Addressable S1 Crash Avoidance Safety Benefits in terms of Crashes

PCAM Scenario	Pedestrian Size	Pedestrian Speed	Obstruction?	Lighting	System Logic^	Crash Avoidance Effectiveness	GES Crashes Reduced	FARS Crashes Reduced
S1	Adult	Walk	No	Day	AEB	7% - 76%	318 - 3,503	58 - 641
S1	Adult	Run	No	Day	AEB	0% - 68%	N/A*	N/A*
S1	Child	Walk	No	Day	AEB	12% - 90%	93 - 713	4 - 31
S1	Child	Walk	Yes	Day	AEB	0% - 39%	0 - 108	0 - 3
Total Effectiveness of PCAM Addressable S1					**AEB**	**7% - 77%**	**411 - 4,324**	**62 - 675**

^Only results for AEB activation are shown, no driver input or warning. Results between system logic variations yielded minimal differences.
*Only 1 FARS case was identified, therefore there is not enough data to estimate benefits, only effectiveness

Based on the crash avoidance system effectiveness and crash reduction values, it is estimated that PCAM systems can save up to $6,856 million in comprehensive costs and 750 equivalent lives, as shown in Table 28.[41]

[41] Equivalent lives saved is a measure that correlates comprehensive costs reduced to the cost of a fatality. For more information, see Appendix A.

Table 28: PCAM-Addressable S1 Crash Avoidance Safety Benefits in Terms of Costs and Equivalent Lives Saved

PCAM Scenario	Pedestrian Size	Pedestrian Speed	Obstruction?	Lighting	System Logic^	Crash Avoidance Effectiveness	Costs Reduced ($M)	Equivalent Lives Saved
S1	Adult	Walk	No	Day	AEB	7% - 76%	$ 582 - 6,417	64 - 702
S1	Adult	Run	No	Day	AEB	0% - 68%	$ 3*	N/A*
S1	Child	Walk	No	Day	AEB	12% - 90%	$ 51 - 388	6 - 42
S1	Child	Walk	Yes	Day	AEB	0% - 39%	$ 48	5
Total Effectiveness of PCAM Addressable S1					**AEB**	**7% - 77%**	**$ 633 - 6,856**	**69 - 750**

^Only results for AEB activation are shown, no driver input or warning. Results between system logic variations yielded minimal differences.
*Only 1 FARS case was identified over two years, this is benefit is simply the effectiveness multiplied by the average annual comprehensive cost (one half comprehensive cost of one fatality).

Given a crash, PCAM systems could mitigate between 64 and 91 percent of MAIS 2^+ injured pedestrians, and between 76 and 96 percent of MAIS 3^+ injured pedestrians, as shown in Table 29. Again, results are compiled and presented as a range to encompass all three OEM systems. Furthermore, initial effectiveness results showed minimal differences between PCAM system logic; most likely due to the limited time between warning and AEB activation as noted in Section 3.2.4; for this reason, safety benefit results are only shown for AEB activation. For a detailed list of crash mitigation effectiveness broken down by OEM system and system logic, refer to Table 22 and Table 26.

Table 29: PCAM Addressable S1 Crash Mitigation Safety Benefits in Terms of Pedestrian Injuries

	PCAM Scenario	Pedestrian Size	Pedestrian Speed	Obstruction?	Lighting	Harm Measure	Crash Mitigation Effectiveness	Injuries Reduced
AEB Only^	S1	Adult	Walk	No	Day	MAIS 2+	67% - 92%	1,051 - 1,448
						MAIS 3+	79% - 96%	873 - 1,068
	S1	Adult	Run	No	Day	MAIS 2+	46% - 88%	N/A*
						MAIS 3+	54% - 92%	N/A*
	S1	Child	Walk	No	Day	MAIS 2+	46% - 89%	69 - 133
						MAIS 3+	38% - 91%	27 - 65
	S1	Child	Walk	Yes	Day	MAIS 2+	41% - 73%	21 - 38
						MAIS 3+	52% - 87%	12 - 21
	Total Effectiveness of PCAM Addressable Total S1					**MAIS 2+**	**64% - 91%**	**1,142 - 1,620**
						MAIS 3+	**76% - 96%**	**912 - 1,154**

^Only results for AEB activation are shown, no driver input or warning. Results between system logic variations yielded minimal differences.
*Only 1 FARS case was identified; therefore, there is not enough data to estimate benefits, only effectiveness

Based on the crash mitigation system effectiveness and pedestrian injuries reduced, it is estimated that PCAM systems can save up to $8,206 million in comprehensive costs and 897 equivalent lives, as shown in Table 30.

Table 30: PCAM Addressable S1 Crash Mitigation Safety Benefits in Terms of Costs and Equivalent Lives Saved

	PCAM Scenario	Pedestrian Size	Pedestrian Speed	Obstruction?	Lighting	Harm Measure	Crash Mitigation Effectiveness	Costs Reduced ($M)	Equivalent Lives Saved
AEB Only	S1	Adult	Walk	No	Day	MAIS 2+	67% - 92%	$ 5,514 - 7,594	603 - 830
						MAIS 3+	79% - 96%	$ 6,347 - 7,767	694 - 849
	S1	Adult	Run	No	Day	MAIS 2+	46% - 88%	$ 2 – 4*	N/A*
						MAIS 3+	54% - 92%	$ 2 – 4*	N/A*
	S1	Child	Walk	No	Day	MAIS 2+	46% - 89%	$ 188 - 364	21 - 40
						MAIS 3+	38% - 91%	$ 143 - 344	16 - 38
	S1	Child	Walk	Yes	Day	MAIS 2+	41% - 73%	$ 47 - 84	5 - 9
						MAIS 3+	52% - 87%	$ 54 - 91	6 - 10
	Total Effectiveness of PCAM Addressable Total S1					**MAIS 2+**	**64% - 91%**	**$ 5,751 - 8,046**	**629 - 880**
						MAIS 3+	**76% - 96%**	**$ 6,547 - 8,206**	**716 - 897**

^Only results for AEB activation are shown, no driver input or warning. Results between system logic variations yielded minimal differences.
*Only 1 FARS case was identified over two years, this is benefit is simply the effectiveness multiplied by the average annual comprehensive cost (one half comprehensive cost of one fatality).

4.2 S4 – Vehicle Going Straight and Pedestrian Walking With/Against Traffic or Stationary in/Adjacent Road

Similar to S1, these crashes can occur under various conditions, as depicted in previous research [5]. However, to accurately assess system effectiveness E_A and E_M from Equations **(1)** and **(5)**, a detailed connection was made between the baseline crashes, objective test data, and input into the simulation.

4.2.1 S4 Target Crash Population

Table 31 shows detailed crash statistics for PCAM-addressable S4 crashes. For all PCAM-addressable S4 crashes, approximately 26 percent of GES crashes and 28 percent of FARS crashes contained sufficient and correlating data. These crashes account for 28 percent of PCAM-applicable S4 comprehensive costs. Further information on cost calculations can be found in Appendix A. The remaining proportion of crashes did not have sufficient crash data or data that correlated to applicable characterization test results. Thus, this analysis assumes conservatively that PCAM systems have no safety benefit in those S4 remaining crashes.[42]

[42] Although PCAM systems may work in other conditions, for example low light or night time conditions, there was insufficient system performance information to predict the potential effectiveness of a PCAM system in these conditions therefore it is estimated that there is no change.

Table 32 shows detailed injury information for the crashes mentioned. These S4 crashes represent 29 percent of MAIS 2^+ and 28 percent of MAIS 3^+ injured pedestrians. The table also illustrates the same percentages for comprehensive costs associated with pedestrian injuries. The low proportion of crashes addressed is due to the lack of characterization testing done within S4 (e.g., no walking towards traffic, no night time or low light conditions, and no adverse weather testing).

Table 31: Two-Year Annual Average Number (2011 to 2012) of S4 Target Crashes

PCAM Scenario	Pedestrian Size	Pedestrian Speed	Obstruction?	Lighting	GES Crashes	FARS Crashes	Costs (Million $)
S4	Adult	Stationary	No	Day	300	100	$ 967
S4	Adult	Walking With Traffic	No	Day	471	72	$ 763
Percent of PCAM-Addressable S4					**26%**	**28%**	**28%**

Table 32: Two-Year Annual Average Number (2011 to 2012) of Injured Pedestrians in S4 Target Crashes

PCAM Scenario	Pedestrian Size	Pedestrian Speed	Obstruction?	Lighting	MAIS 2+		MAIS 3+	
					Pedestrians Injured	Costs (Million $)	Pedestrians Injured	Costs (Million $)
S4	Adult	Stationary	No	Day	160	$ 959	125	$ 945
S4	Adult	Walking With Traffic	No	Day	187	$ 750	120	$ 723
Percent of PCAM-Addressable S4					**29%**	**28%**	**28%**	**28%**

Breaking down the crashes in Table 31, only a percentage of these crashes contained enough information to be reconstructed (i.e., travel speed information). The number of applicable GES crashes and their representative annual weight and the number of applicable FARS crashes are summarized in Table 33.

Table 33: Number of Total S4 Crashes With Available Information for Detailed Crash Reconstruction from 2011 and 2012 Crash Data*

Pedestrian Size	Pedestrian Speed	PCAM Scenario	Obstruction?	Lighting	GES		# FARS Cases
					# Cases	Sum of Weights	
S4	Adult	Stationary	No	Day	17	305	125
S4	Adult	Walking With Traffic	No	Day	13	225	63

*These values are total values across two years, as opposed to annual averages

Of the available cases for reconstruction, travel speed information was used to correlate the harm sustained to the pedestrian in baseline crashes. Table 34 shows a sample distribution of vehicle travel speed information in S4 with an adult stationary in the roadway during the day with no obstruction. This information helps to determine the baseline harm sustained to the pedestrian as seen in Equation (7).

Table 34: Travel Speed Distribution of Actual GES and FARS Crash Data for an Adult Stationary in S4 During the Day With No Obstruction

Speed Bin (mph)		GES	FARS
1	**0 < x ≤ 5**	4.1%	0.8%
2	**5 < x ≤ 10**	0.0%	2.4%
3	**10 < x ≤ 15**	11.0%	1.6%
4	**15 < x ≤ 20**	7.3%	2.4%
5	**20 < x ≤ 25**	17.4%	4.8%
6	**25 < x ≤ 30**	4.0%	9.6%
7	**30 < x ≤ 35**	11.3%	12.0%
8	**35 < x ≤ 40**	0.0%	16.0%
9	**40 < x ≤ 45**	41.6%	16.0%
10	**45 < x ≤ 50**	0.0%	8.0%
11	**50 < x ≤ 55**	0.0%	7.2%
12	**55 < x ≤ 60**	0.0%	4.8%
13	**60 < x ≤ 65**	3.3%	5.6%
14	**65 < x ≤ 70**	0.0%	2.4%
15	**70 < x ≤ 75**	0.0%	0.0%
16	**75 < x**	0.0%	6.4%

The same regression model was run as described in Section 4.1.1. Sample results for the regression model are given in Table 35 for an S4 with an adult stationary in the roadway during the day with no obstruction. The two curves (actual data and smoothed function) are plotted in Figure 19 and Figure 20 for GES and FARS databases, respectively. The curve fitting was crucial for S4, as the number of cases available was small which created many peaks and drops in the actual data. The full list of results and plots can be seen in Appendix E. These results are used to determine the baseline harm sustained to the pedestrian as seen in Equation (7).

Table 35: Observed Statistics for Normal Distribution Function of Baseline Crash Data for an Adult Stationary in S4 During the Day With No Obstruction, Under the AEB Only Treatment

Variable		GES	FARS
Mean	μ	2.91	8.30
Standard Deviation	σ	0.80	3.06

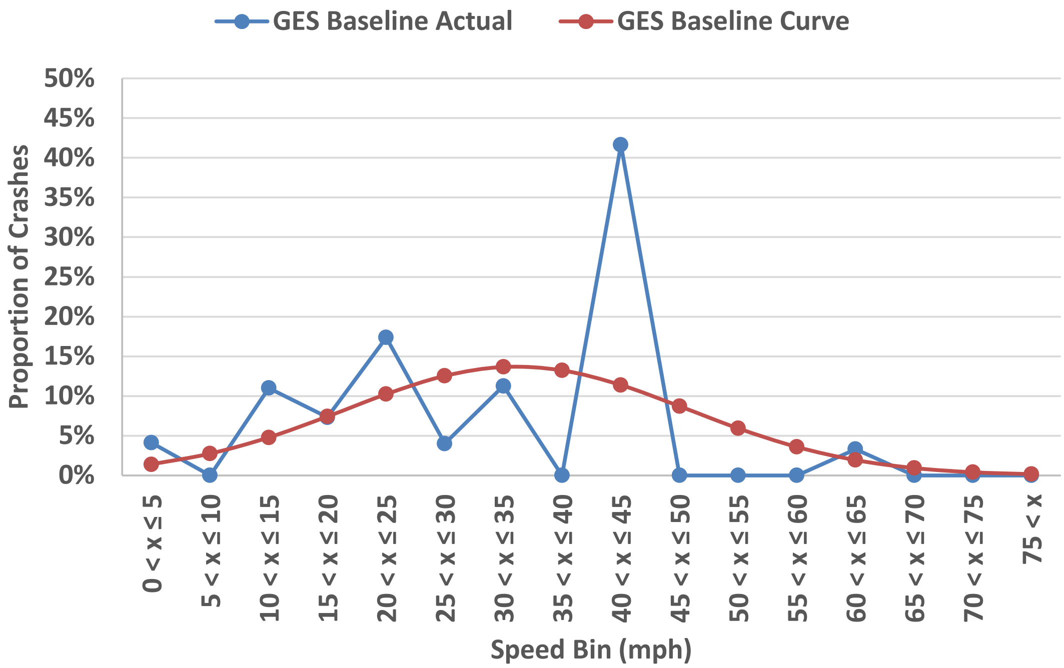

Figure 19: Plots of Normal Distribution Function Compared to Actual GES Data for an Adult Stationary in S4 During the Day With No Obstruction, Under the AEB Only Treatment

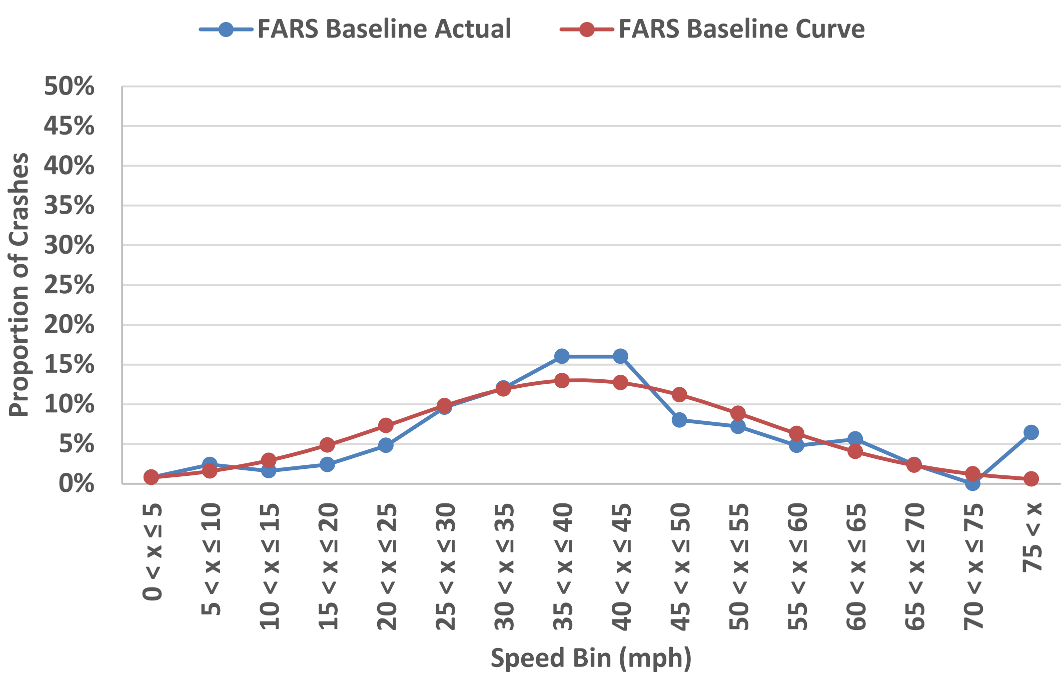

Figure 20: Plots of Normal Distribution Function Compared to Actual FARS Data for an Adult Stationary in S4 During the Day With No Obstruction, Under the AEB Only Treatment

4.2.2 PCAM Crash Avoidance Effectiveness in S4

The method to estimate PCAM crash avoidance effectiveness in S4 superimposed performance data from the performance testing of three production systems onto reconstructed crashes from GES and FARS using computer simulation. Furthermore, each production system was simulated under three variations of the PCAM system (i.e., AEB only, first braking response, and best braking response). Table 35 shows the results from the simulation for the various S4 configurations. These results represent $\boldsymbol{E_A}$ in Equation **(**4**)**.

Results show that PCAM systems are potentially better at tracking moving pedestrians. Furthermore, OEM 2 seems to provide better results than any other OEM system; this is could be due to quality of hardware or software algorithms, as all OEMs used at least stereo cameras (OEM 1 and OEM 3 added radar). Finally, considering the minimal amount of time between warning and AEB activation, the difference in system logic yielded marginal improvements.

Table 36: Crash Avoidance Effectiveness of PCAM Systems in S4

PCAM Scenario	Pedestrian Size	Pedestrian Speed	Obstruction?	Lighting	System Logic	GES			FARS		
						OEM 1	OEM 2	OEM 3	OEM 1	OEM 2	OEM 3
S4	Adult	Stationary	No	Day	AEB	49%	64%	53%	39%	51%	34%
					First	49%	64%	53%	38%	50%	34%
					Best	50%	65%	53%	39%	51%	34%
S4	Adult	Walking With Traffic	No	Day	AEB	70%	100%	95%	22%	59%	46%
					First	69%	99%	96%	22%	58%	46%
					Best	70%	100%	96%	22%	59%	46%

4.2.3 PCAM Crash Mitigation Effectiveness in S4

PCAM systems may mitigate injury to the pedestrian if a crash occurs, by reducing the vehicle's travel speed through AEB activation and earlier driver response. These results are curve fitted and used to determine harm sustained to the pedestrian with PCAM intervention in Equation (8). The same regression model was used for S4 as described in Section 4.1.3. Appendix F shows the results of this regression model.

Table 37 shows the results for harm reduction, based on Equation **(**6**)**. These results are the effectiveness in reducing the harm ratio, independent of crash avoidance. Again, it can be seen that the warning provided minimal results beyond AEB. Red-highlighted cells show that there was 100 percent harm reduction for crash mitigation. This is due to the fact that this OEM system provided 100 percent crash avoidance, resulting in zero pedestrian harm.

Table 38 shows the results of crash mitigation effectiveness, based on Equation **(**5**)**. These results incorporate harm reduction and crash avoidance effectiveness. Results show that PCAM systems provided better effectiveness with a walking pedestrian, as opposed to a constantly stationary pedestrian.

Table 37: Harm Reduction Ratios of PCAM Systems in S4

	PCAM Scenario	Pedestrian Size	Pedestrian Speed	Obstruction?	Lighting	Harm Measure	GES			FARS		
							OEM 1	OEM 2*	OEM 3	OEM 1	OEM 2	OEM 3
AEB Only	S4	Adult	Stationary	No	Day	MAIS 2+	0.68	0.67	0.73	0.71	0.71	0.69
						MAIS 3+	0.79	0.78	0.86	0.83	0.82	0.80
	S4	Adult	Walking With Traffic	No	Day	MAIS 2+	0.73	1.00	0.67	0.71	0.73	0.72
						MAIS 3+	0.88	1.00	0.84	0.82	0.83	0.83

	PCAM Scenario	Pedestrian Size	Pedestrian Speed	Obstruction?	Lighting	Harm Measure	GES			FARS		
							OEM 1	OEM 2*	OEM 3	OEM 1	OEM 2	OEM 3
First Braking	S4	Adult	Stationary	No	Day	MAIS 2+	0.76	0.79	0.86	0.71	0.71	0.69
						MAIS 3+	0.73	0.85	0.67	0.83	0.82	0.80
	S4	Adult	Walking With Traffic	No	Day	MAIS 2+	0.88	0.93	0.83	0.71	0.73	0.72
						MAIS 3+	0.76	0.79	0.86	0.82	0.83	0.83

	PCAM Scenario	Pedestrian Size	Pedestrian Speed	Obstruction?	Lighting	Harm Measure	GES			FARS		
							OEM 1	OEM 2*	OEM 3	OEM 1	OEM 2	OEM 3
Best Braking	S4	Adult	Stationary	No	Day	MAIS 2+	0.67	0.67	0.73	0.71	0.73	0.69
						MAIS 3+	0.78	0.78	0.86	0.83	0.84	0.80
	S4	Adult	Walking With Traffic	No	Day	MAIS 2+	0.73	1.00	0.58	0.71	0.73	0.72
						MAIS 3+	0.88	1.00	0.74	0.82	0.83	0.83

*For OEM 2, crash avoidance was estimated to be 100 percent for pedestrian walking with traffic; therefore this reduction ratio would result in 0 as the numerator (i.e., no harm in treatment due to no crashes).

Table 38: Crash Mitigation Effectiveness of PCAM Systems in S4

	PCAM Scenario	Pedestrian Size	Pedestrian Speed	Obstruction?	Lighting	Harm Measure	GES			FARS		
							OEM 1	OEM 2	OEM 3	OEM 1	OEM 2	OEM 3
AEB Only	S4	Adult	Stationary	No	Day	MAIS 2+	84%	88%	87%	83%	86%	80%
						MAIS 3+	89%	92%	93%	89%	91%	87%
	S4	Adult	Walking With Traffic	No	Day	MAIS 2+	92%	100%	98%	78%	89%	85%
						MAIS 3+	96%	100%	99%	86%	93%	91%

	PCAM Scenario	Pedestrian Size	Pedestrian Speed	Obstruction?	Lighting	Harm Measure	GES			FARS		
							OEM 1	OEM 2	OEM 3	OEM 1	OEM 2	OEM 3
First Braking	S4	Adult	Stationary	No	Day	MAIS 2+	82%	88%	87%	82%	86%	80%
						MAIS 3+	88%	92%	93%	89%	91%	87%
	S4	Adult	Walking With Traffic	No	Day	MAIS 2+	92%	100%	99%	77%	89%	85%
						MAIS 3+	96%	100%	99%	86%	93%	91%

	PCAM Scenario	Pedestrian Size	Pedestrian Speed	Obstruction?	Lighting	Harm Measure	GES			FARS		
							OEM 1	OEM 2	OEM 3	OEM 1	OEM 2	OEM 3
Best Braking	S4	Adult	Stationary	No	Day	MAIS 2+	84%	88%	87%	83%	87%	80%
						MAIS 3+	89%	92%	93%	89%	92%	87%
	S4	Adult	Walking With Traffic	No	Day	MAIS 2+	92%	100%	98%	78%	89%	85%
						MAIS 3+	96%	100%	99%	86%	93%	91%

4.2.4 S4 Safety Benefits

Based on the results from this analysis, the tested PCAM systems can potentially avoid between 27 and 86 percent of GES- and FARS- addressable S4 crashes. Table 39 shows the results for crash avoidance and the annual number of GES and FARS crashes that could be reduced from a PCAM system. This estimate is based on system performance data from characterization tests and limited crash reconstructions for S4. A small subset of crashes could accurately be correlated to characterization test. Furthermore, the wide range of system effectiveness values is due to the variations in the three OEM system performance results. Results are compiled and presented as a range to encompass all three OEM systems. Results for the two databases, GES and FARS were also integrated to identify the range of results. Results show that there is little difference between PCAM system logic; most likely due to the limited time between warning and AEB activation as noted in Section 3.2.4. For a detailed breakdown of crash avoidance effectiveness estimates by OEM system, database, and system logic refer to Table 36.

Table 39: PCAM-Addressable S4 Crash Avoidance Safety Benefits in terms of Crashes

PCAM Scenario	Pedestrian Size	Pedestrian Speed	Obstruction?	Lighting	System Logic^	Crash Avoidance Effectiveness	GES Crashes Reduced	FARS Crashes Reduced
S4	Adult	Stationary	No	Day	AEB	34% - 64%	103 - 192	34 - 64
S4	Adult	Walking With Traffic	No	Day	AEB	22% - 100%	105 - 471	16 - 72
Total Effectiveness of PCAM-Addressable Total S4					**AEB**	**27% - 86%**	**208 - 663**	**50 - 135**

^Only results for AEB activation are shown, no driver input or warning. Results between system logic variations yielded minimal differences.

Based on the crash avoidance system effectiveness and crash reduction values, it is estimated that PCAM systems can save up to $1,380 million in comprehensive costs and 151 equivalent lives, as shown in Table 40.

Table 40: PCAM-Addressable S4 Crash Avoidance Safety Benefits in Terms of Costs and Equivalent Lives Saved

PCAM Scenario	Pedestrian Size	Pedestrian Speed	Obstruction?	Lighting	System Logic^	Crash Avoidance Effectiveness	Costs Reduced ($M)	Equivalent Lives Saved
S4	Adult	Stationary	No	Day	AEB	34% - 64%	$ 332 - 618	36 - 68
S4	Adult	Walking With Traffic	No	Day	AEB	22% - 100%	$ 170 – 763	19 - 83
Total Effectiveness of PCAM-Addressable Total S4					**AEB**	**27% - 86%**	**$ 501 - 1,380**	**55 - 151**

^Only results for AEB activation are shown, no driver input or warning. Results between system logic variations yielded minimal differences.

Given a crash, PCAM systems may mitigate between 79 and 94 percent of MAIS 2^+ and between 86 and 97 percent of MAIS 3^+ injured pedestrians, as shown in Table 41. Again, results are compiled and presented as a range to encompass all three OEM systems. Furthermore, initial effectiveness results showed minimal differences between PCAM system logic; most likely due to the limited time between warning and AEB activation as noted in Section 3.2.4; for this reason safety benefit results are only shown for AEB activation. For a detailed list of crash mitigation effectiveness broken down by OEM system and system logic, refer to Table 38.

Table 41: PCAM-Addressable S4 Crash Mitigation Safety Benefits in Terms of Crashes

	PCAM Scenario	Pedestrian Size	Pedestrian Speed	Obstruction?	Lighting	Harm Measure	Crash Mitigation Effectiveness	Injuries Reduced
AEB Only^	S4	Adult	Stationary	No	Day	MAIS 2+	80% - 88%	128 - 141
						MAIS 3+	87% - 93%	109 - 116
	S4	Adult	Walking With Traffic	No	Day	MAIS 2+	78% - 100%	145 - 187
						MAIS 3+	86% - 100%	103 - 120
	Total Effectiveness of PCAM-Addressable Total S4					**MAIS 2+**	**79% - 94%**	**273 - 329**
						MAIS 3+	**86% - 97%**	**212 - 236**

^Only results for AEB activation are shown, no driver input or warning. Results between system logic variations yielded minimal differences.

Based on the crash mitigation system effectiveness and pedestrian injuries reduced, it is estimated that PCAM systems can save up to $1,604 million in comprehensive costs and 175 equivalent lives, as shown in Table 42.

Table 42: PCAM-Addressable S4 Crash Mitigation Safety Benefits in Terms of Costs and Equivalent Lives Saved

	PCAM Scenario	Pedestrian Size	Pedestrian Speed	Obstruction?	Lighting	Harm Measure	Crash Mitigation Effectiveness	Costs Reduced ($M)	Equivalent Lives Saved
AEB Only^	S4	Adult	Stationary	No	Day	MAIS 2+	80% - 88%	$ 764 - 844	84 - 92
						MAIS 3+	87% - 93%	$ 822 - 881	90 - 96
	S4	Adult	Walking With Traffic	No	Day	MAIS 2+	78% - 100%	$ 581 - 750	64 - 82
						MAIS 3+	86% - 100%	$ 621 - 723	68 - 79
	Total Effectiveness of PCAM-Addressable Total S4					**MAIS 2+**	**79% - 94%**	**$ 1,346 - 1,594**	**147 - 174**
						MAIS 3+	**86% - 97%**	**$ 1,443 - 1,604**	**158 - 175**

^Only results for AEB activation are shown, no driver input or warning. Results between system logic variations yielded minimal differences.

5 CONCLUSION

This report developed and applied a methodology to estimate the potential safety benefits for PCAM systems. These systems are vehicle-based pedestrian detection systems that can automatically apply the vehicle brakes to avoid a collision or mitigate the impact speed. Safety benefits are estimated in terms of reductions in the number of all annual vehicle-pedestrian crashes, annual vehicle-pedestrian fatal crashes, annual injured pedestrians at MAIS 2^+ and MAIS 3^+ levels, annual comprehensive costs, and annual equivalent lives. This methodology focused on two common pre-crash scenarios:

- S1 – Vehicle going straight and pedestrian crossing the roadway.
- S4 – Vehicle going straight and pedestrian in or adjacent to the roadway, stationary or moving with or against traffic.

GES and FARS crash databases were queried to identify and characterize vehicle-pedestrian crashes. Based on 2011 and 2012 crash statistics, light-vehicles struck a pedestrian in the first event in an annual average of 62,917 vehicle-pedestrian crashes of all severities, 3,337 fatal vehicle-pedestrian crashes, and $40,599,000,000 in comprehensive costs. Of these crashes, approximately 52 percent of all vehicle-pedestrian crashes and 90 percent of all fatal vehicle-pedestrian crashes belong to S1 and S4 scenarios, as shown in Table 43. Further, these crashes accounted for $33 million in comprehensive costs, roughly 82 percent of the cost of all vehicle-pedestrian crashes.

Table 43: Annual Average Vehicle-Pedestrian Crash Problem

Scenario	Vehicle Maneuver	Pedestrian Maneuver	GES Crash Frequency	FARS Crash Frequency	**Costs** (Million $)
S1	Going Straight	Crossing Roadway	23,558	2,029	$ 22,791
S4	Going Straight	Walking Along/Against Traffic	9,340	977	$ 10,652
Percent Total of Annual Light-Vehicle Pedestrian Problem*			**52%**	**90%**	**82%**

*Light-Vehicle struck a pedestrian in the first event of a crash

Based on 2011 and 2012 crash statistics, light-vehicles struck a pedestrian in the first event in a crash and resulted in an annual average of 13,058 injured pedestrians at the MAIS 2^+ level resulting in $38,781,000,000 in comprehensive costs. For injured pedestrians at the MAIS 3^+ level, these crashes resulted in an annual average of 6,770 injured pedestrians resulting in an annual average of $36,368,000,000 in comprehensive costs. Table 44 shows that these crashes resulted in 67 percent of all MAIS 2^+ and 76 percent of all MAIS 3^+ injured pedestrians. These injuries accounted for over 80 percent of all comprehensive costs associated with pedestrian injury.

Table 44: Annual Average Pedestrian Injury Problem

Scenario	Vehicle Maneuver	Pedestrian Maneuver	MAIS 2+		MAIS 3+	
			Pedestrians Injured	Costs (Million $)	Pedestrians Injured	Costs (Million $)
S1	Going Straight	Crossing Roadway	6,063	$ 22,137	3,553	$ 21,134
S4	Going Straight	Walking Along/Against Traffic	2,658	$ 10,396	1,626	$ 9,983
Percent Total of Annual Light-Vehicle Pedestrian Problem*			**67%**	**84%**	**76%**	**86%**

*Light-Vehicle struck a pedestrian in the first event of a crash

The analysis of production and near-term PCAM systems provided information on their operational boundaries and capabilities as well as countermeasure profiles and basic activation algorithms (e.g., suppression techniques). The crash data were further refined to determine that a PCAM-addressable crash included a light vehicle moving forward, striking the pedestrian in the first event by its front side, and not attempting any avoidance maneuver.

Table 45 and Table 46 shows the PCAM-addressable crash population using the above criteria. These crashes represent the target baseline vehicle-pedestrian crash problem for PCAM systems. These crashes may directly benefit from PCAM systems (e.g., use and operational conditions). The number of crashes decreases significantly as more filters are applied. Crash databases rely on police-reports to identify certain information, therefore many variables may be coded as unknown or labelled differently (e.g., according to police and witness statements).

Table 45: Baseline PCAM-Addressable Crashes and Costs

Scenario	Vehicle Maneuver	Pedestrian Maneuver	GES Crash Frequency	FARS Crash Frequency	**Costs** (Million $)
S1	Going Straight	Crossing Roadway	7,481	1,396	$ 14,072
S4	Going Straight	Walking Along/Against Traffic	2,950	620	$ 6,226
Percent Total of Annual Light-Vehicle Pedestrian Problem*			**49%**	**92%**	**50%**

*Light-Vehicle struck a pedestrian in the first event of a crash

Table 46: Baseline PCAM-Addressable Pedestrian Injuries and Costs

Scenario	Vehicle Maneuver	Pedestrian Maneuver	MAIS 2+		MAIS 3+	
			Pedestrians Injured	Costs (Million $)	Pedestrians Injured	Costs (Million $)
S1	Going Straight	Crossing Roadway	2,682	$13,862	1,879	$13,541
S4	Going Straight	Walking Along/Against Traffic	1,207	$6,150	860	$6,012
Percent Total of Annual Light-Vehicle Pedestrian Problem*			**72%**	**52%**	**82%**	**54%**

*Light-Vehicle struck a pedestrian in the first event of a crash

Three production PCAM systems were tested for warning and AEB capabilities, and were characterized by various testing conditions (i.e., vehicle parameters, pedestrian parameters, and environmental conditions). These conditions were correlated to available baseline crash information to obtain system effectiveness measures for the production PCAM systems; PCAM systems were further defined by three different system logic implementations: AEB only, first braking response, and best braking response. Using a Monte Carlo simulation to reconstruct available crashes (i.e., known travel speed) and superimposing empirical system performance data onto these crashes, estimates of PCAM system effectiveness were obtained. PCAM systems can be effective through crash avoidance, and if a crash occurs, through crash mitigation by speed reduction. Table 47 and Table 48 shows crash avoidance effectiveness ranges for the three production PCAM systems across the various target crash measures.[43] These measures include GES and FARS crashes, comprehensive costs, and equivalent lives. Crash avoidance effectiveness is tied to data availability of historical crashes and testing conditions (e.g., small sample size of crash data). Overall, the estimate range can vary significantly from 10 to 78 percent for the target crash population. The variation is due to the method of analyzing all three production PCAM system test results. All three production PCAM systems were analyzed, as no one single system out-performed the other. Furthermore, all three production PCAM systems were considered equally distributed in our assumption of 100 percent full deployment in the light-vehicle fleet.

Table 47: Crash Avoidance Effectiveness and Safety Benefits for PCAM-Addressable Crashes

Scenario	System Logic^	Crash Avoidance Effectiveness	GES Crashes Reduced	FARS Crashes Reduced
S1	AEB	7% - 77%	411 - 4,324	62 - 675
S4	AEB	27% - 86%	208 - 663	50 - 135
All PCAM-Addressable	**AEB**	**10% - 78%**	**619 - 4,987**	**112 - 810**

^Only results for AEB activation are shown, no driver input or warning. Results between system logic variations yielded minimal differences.

Table 48: Crash Avoidance Effectiveness and Safety Benefits for PCAM-Addressable Crash Costs and Equivalent Lives Saved

Scenario	System Logic^	Crash Avoidance Effectiveness	Costs Reduced ($M)	Equivalent Lives Saved
S1	AEB	7% - 77%	$ 633 - 6,856	69 - 750
S4	AEB	27% - 86%	$ 501 - 1,380	55 - 151
All PCAM-Addressable	**AEB**	**10% - 78%**	**$ 1,135 - 8,237**	**124 - 901**

^Only results for AEB activation are shown, no driver input or warning. Results between system logic variations yielded minimal differences.

Table 49 lists the crash mitigation effectiveness for injured pedestrians at MAIS 2^+ and MAIS 3^+ injury levels, associated comprehensive costs, and equivalent lives saved with respect to those costs. These effectiveness estimates incorporate the results of the crash avoidance effectiveness estimates in addition to the harm reduction effectiveness estimates. Again, these estimates carry a range of potential crash mitigation effectiveness. This is due to the test results of three different production PCAM systems being analyzed. Furthermore, observed results showed no difference between system logic implementation, therefore AEB-only results are shown.

[43] Only results for the AEB-Only system logic are shown. Observed results showed that there were no differences when implementing a warning, due to the limited time between a warning and AEB activation (little time for driver input).

Table 49: Crash Mitigation Effectiveness and Safety Benefits for PCAM-Addressable Crashes

	Scenario	Harm Measure	Crash Mitigation Effectiveness	Pedestrian Injuries Reduced	Costs Reduced ($M)	Equivalent Lives Saved
AEB Only^	S1	MAIS 2+	64% - 91%	1,142 - 1,620	$ 5,751 - 8,046	629 - 880
		MAIS 3+	76% - 96%	912 - 1,154	$ 6,547 - 8,206	716 - 897
	S4	MAIS 2+	79% - 94%	273 - 329	$ 1,346 - 1,594	147 - 174
		MAIS 3+	86% - 97%	212 - 236	$ 1,443 - 1,604	158 - 175
	All PCAM-Addressable	**MAIS 2+**	**67% - 92%**	**1,415 - 1,948**	**$ 7,097 - 9,640**	**776 - 1,054**
		MAIS 3+	**77% - 96%**	**1,124 - 1,391**	**$ 7,990 - 9,810**	**874 - 1,073**

^Only results for AEB activation are shown, no driver input or warning. Results between system logic variations yielded minimal differences.

Overall, this report estimates that PCAM systems could provide a 10 to 78 percent crash avoidance effectiveness rate, when compared to PCAM-addressable crashes (i.e., safety benefits divided by PCAM-addressable and test correlated S1 and S4 crash population). This crash avoidance effectiveness rate translates to the capability of potentially preventing between 1 to 8 percent of all vehicle-pedestrian crashes where light-vehicle strikes a pedestrian in the first event (i.e., safety benefits divided by light-vehicle striking pedestrian in first event crash population), reducing between 620 and 5,000 annual crashes. A detailed breakdown of crash statistics and how they are incorporated into the safety benefits and system effectiveness estimates are shown in Figure 21. Moreover, these systems can reduce between 110 and 810 fatal vehicle-pedestrian crashes (using similar calculations from Figure 21 this translates to approximately 3% to 24% of all annual fatal pedestrian crashes where a light-vehicle strikes the pedestrian in the first event). These crashes account for anywhere from $1,135 and $8,261 million in comprehensive costs, which can translate to between 124 and 903 equivalent lives saved.[44]

[44] Comprehensive costs estimate includes lost productivity, medical costs, legal and court costs, emergency service costs, insurance administration costs, travel delay, property damage, and workplace losses

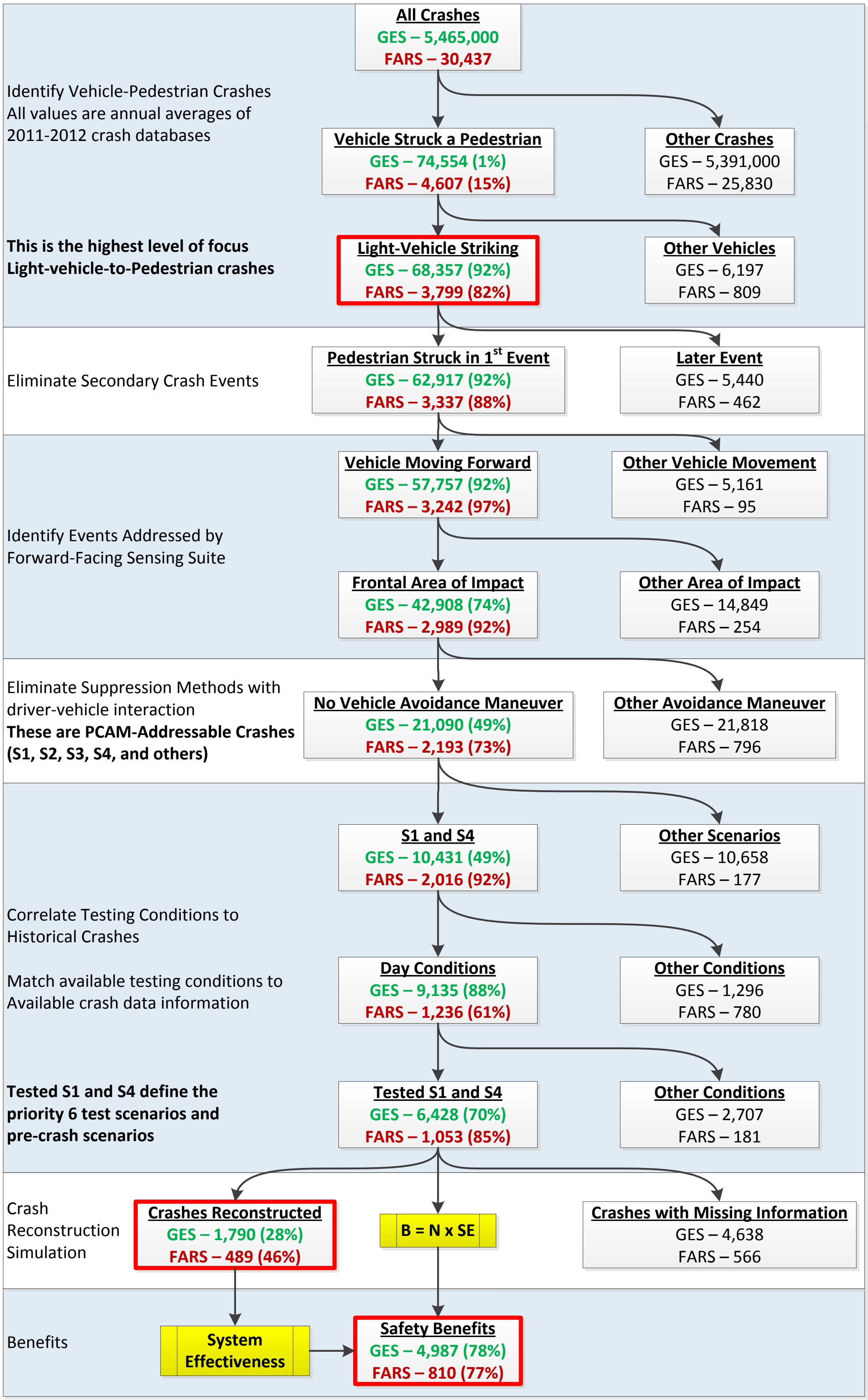

Figure 21: Detailed Breakdown of Crashes Statistics and Relationship to Safety Benefits

If a crash is unavoidable, PCAM systems could reduce the resulting number of injured pedestrians through impact speed reduction. PCAM systems are estimated to have crash mitigation effectiveness between 67 and 92 percent of MAIS 2^+ injured pedestrians (when comparing to PCAM-addressable and test correlated S1 and S4 crash population), resulting in an annual reduction between 1,400 and 1,950 injured pedestrians. This number of reduced pedestrian injuries accounts for 11 to 15 percent of all annual pedestrians injured at MAIS 2^+ (when comparing to light-vehicle striking pedestrian in first event crash population). For MAIS 3^+ injured pedestrians, PCAM systems could reduce between 1,100 and 1,400 injured pedestrians annually, with a crash mitigation effectiveness between 77 and 96 percent (using a similar mathematical approach from MAIS 2^+). This number of reduced pedestrian injuries accounts for 16 to 21 percent of all annual pedestrians injured at MAIS 3^+. This reduction in pedestrian injuries translates to costs between $7,000 and $9,800 million dollars saved, correlating to between 776 and 1,073 equivalent lives saved.

5.1 Remarks

The methodology presented in this report to estimate the safety benefits for PCAM safety systems relied on the availability and accuracy of real-world data. Ideally, safety benefits would be estimated from empirical crash data over the course of multiple years, comparing crash statistics of vehicle-pedestrian crashes without a PCAM system to crashes with a PCAM system. However, with the current state of crash data and collection methods, information is unavailable to estimate PCAM safety benefits in this method. Future considerations may be made to amend the data collection method to address any deficiencies in the crash data. Therefore, this methodology supplemented historical crash data with objective testing of production vehicle systems and previous literature/research. This information was input into a simulation to compare historical vehicle-pedestrian crashes with synthetic crashes, superimposing PCAM system performance on these historical crashes. Using this method and the limited data available, safety benefits estimates are presented at a high level.

Further research and information to supplement the existing data will strengthen and refine the safety benefits derived in this report. For example, objective testing was limited to only three production vehicle systems under six specific conditions. The performance of these three systems was not indicative of system performance for other vehicle systems using other technology (e.g., using laser in place of or in addition to radar and camera). Furthermore, as the technology within PCAM systems continues to improve over time, these three systems may not be representative of future technology. Next, the limited objective testing conditions may not take advantage of the full operational capabilities of these PCAM systems. Due to the unknown performance of PCAM systems in other scenarios (i.e., S2 and S3) and other conditions (e.g., adverse weather or minimal lighting conditions), it could not be assumed that PCAM systems will have a positive (or negative) safety benefit. Not being able to correlate testing conditions to historical crashes required this report to take a conservative approach and assume that a significant amount of crashes may not be addressed by a PCAM system (e.g., no safety benefit for crashes in the dark). Additionally, limited information on driver-vehicle interaction of these PCAM systems required this report to generalize the interaction with three simplified system logic approaches.

As improvements in crash data collection, sensing technology, the deployment of PCAM systems increases, and future research is conducted (system performance testing or human factor based testing[45]), this methodology can be refined and improved over time with more readily available data.

[45] Human factor based testing includes driver performance in vehicle-pedestrian crashes (i.e., reaction time and braking level) and pedestrian performance (e.g., movement behavior while crossing the road or walking along the road, reactions to approaching vehicles).

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APPENDIX A: CONVERSION OF INJURY LEVELS FROM KABCO TO MAIS SCALE

The GES crash database does not provide detailed information regarding injury severity based on the AIS coding scheme. Instead, the GES records injury severity by crash victim on the KABCO scale from police crash reports. Police reports in almost every state use KABCO to classify crash victims as:

- K – Killed
- A – Incapacitating injury
- B – Non-incapacitating injury
- C – Possible injury
- O – No apparent injury
- ISU – Injury Severity Unknown

The KABCO coding scheme allows non-medically trained persons to make on-scene injury assessments without a hands-on examination. However, KABCO ratings are imprecise and inconsistently coded between states and over time. On the other hand, the AIS is an anatomically based, consensus-derived global severity scoring system that classifies each injury by body region according to its relative importance on a 6-point ordinal scale (1 = minor and 6 = maximal). The AIS is the basis for the Injury Severity Score calculation of the multiply injured patient. The AIS was developed by the Association for the Advancement of Automotive Medicine (see www.aaam1.org/ais/ for further information). To estimate injuries based on the MAIS coding structure, a translator derived from 1984–1986 NASS and 2008-2010 CDS data was applied to the GES police-reported injury profile as shown in Table 50 [20].

Table 50: KABCO-to-MAIS Conversion Table

MAIS	Police-Reported Injury Severity System						
	O	C	B	A	K	ISU*	Unknown
0	0.9254	0.2343	0.0834	0.0342	0.0000	0.2153	0.4293
1	0.0726	0.6893	0.7675	0.5520	0.0000	0.6270	0.4103
2	0.0020	0.0639	0.1088	0.2081	0.0000	0.1040	0.0872
3	0.0001	0.0107	0.0319	0.1437	0.0000	0.0386	0.0474
4	0.0000	0.0014	0.0062	0.0397	0.0000	0.0044	0.0061
5	0.0000	0.0001	0.0010	0.0178	0.0000	0.0103	0.0027
Killed	0.0000	0.0003	0.0013	0.0046	1.0000	0.0005	0.0171
Total	1	1	1	1	1	1	1

* ISU = Injured, Severity Unknown

Once injuries are converted from KABCO to MAIS, comprehensive costs can be calculated. Figure 22 below shows the comprehensive costs associated with each MAIS injury level. A fatality is estimated at $9.146M. The comprehensive costs associated with a fatality is also used to determine the equivalent lives measure. This measure estimates the number of equivalent lives associated with a comprehensive cost (which could include other injury severities).

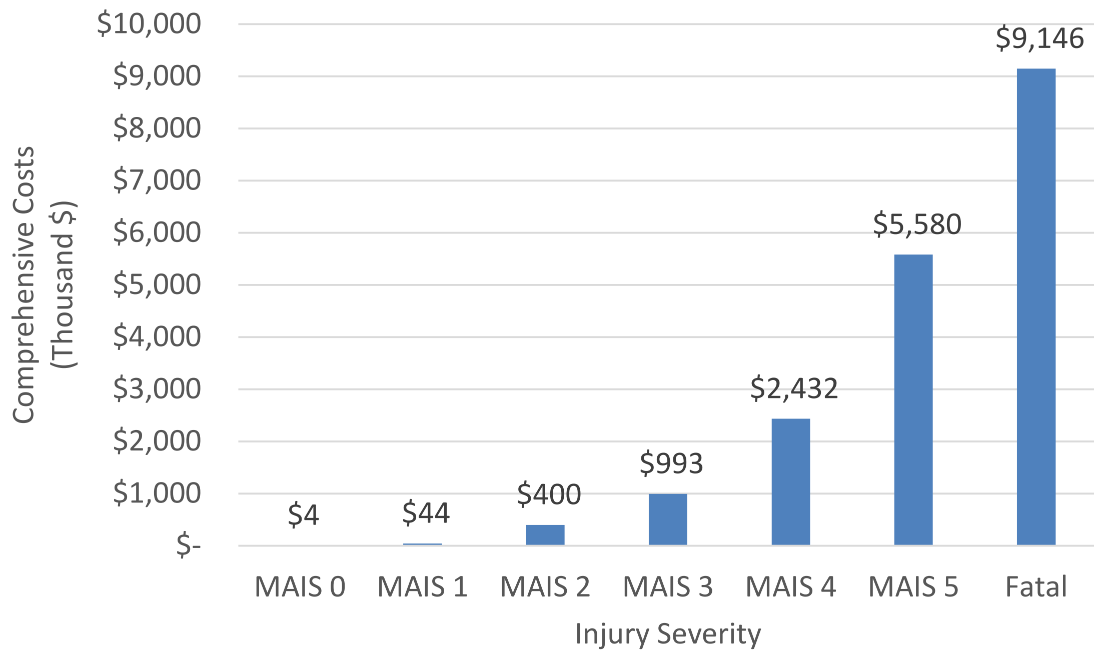

Figure 22: Comprehensive Costs by MAIS Level

APPENDIX B: SPECIAL CRASH INVESTIGATION FOR S1 INCIDENTS

Crash databases do not contain detailed information on crash dynamics (distances, exact speeds). This project tasked a SCI team within NTHSA to investigate relevant S1 (vehicle going straight and pedestrian crossing) crashes and develop detailed crash reconstructions to better understand the dynamics of an S1 crash.[46] The focus of the investigation was to determine TTC for the vehicle when the pedestrian was revealed to the driver (or would be PCAM system). Figure 23 details the TTC measure in a vehicle-pedestrian conflict.

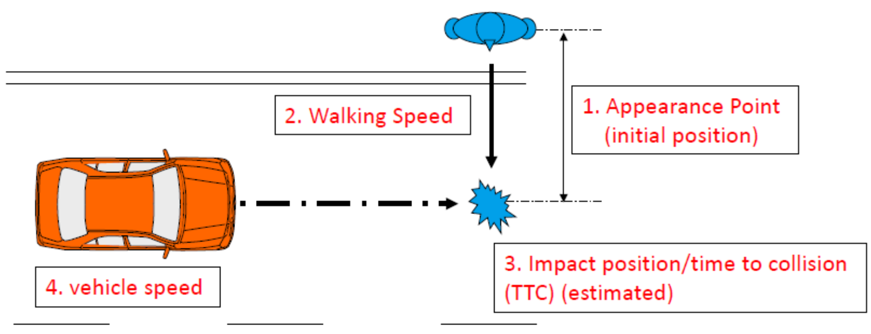

Figure 23: Parameters Needed for an S1 Crash Reconstruction [10]

Information was provided on this scenario in Section 3.1.1. It was found from naturalistic driving, that a vehicle-pedestrian conflict begins around 4.43 seconds prior to the crash [10]. However, this estimate is from naturalistic driving in which no crashes occurred. It is unknown if this estimate holds true for historical crashes. Potentially a pedestrian may run into the road from behind an obstruction unexpectedly (e.g., from between two parked cars at a non-junction), in which case there may be no time for a driver or system to activate (e.g., under 1 s TTC). This estimate will help build a profile for the exact initial conditions for a vehicle going straight-pedestrian crossing. This information will provide immediate confirmation of whether or not a warning or AEB may be effective (e.g., if a pedestrian is revealed below AEB activation time, than a system may not provide benefit).

Further, detailed pre-crash and crash information is provided. Pre-crash information includes exact vehicle travel speeds, driver distractions, pedestrian direction and speeds, and detailed environmental conditions (e.g., lighting, obstructions). Crash information includes detailed vehicle avoidance maneuvers, point-of-contact between vehicle and pedestrian, as well as post-crash information. This information can help build a relationship between crash data, test data, and aid development of future research, testing opportunities, and performance requirements.

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[46] Only S1 was chosen, as this scenario is the most common and can have very different dynamics. This scenario is dependent on line-of-sight and a pedestrian may unexpectedly jump out between cars at the last second, be standing on a curb just off the roadway prior to stepping foot into the vehicle path, or may be visually available for meters off the roadway prior to entering the road. The next most common scenario, S4, it is assumed that the pedestrian is visual as far back as the technology will allow and in constant line-of-sight until the crash.

At the time of this report, 43 detailed crash reconstructions had been provided. These crashes were not dependent on year, pedestrian size, or pedestrian injury, solely on vehicle motion and pedestrian motion (S1).

Overall, the provided a wide range of results for time spent in the road by the pedestrians. Figure 24 shows a histogram for pedestrian reveal TTC as found within the available cases.

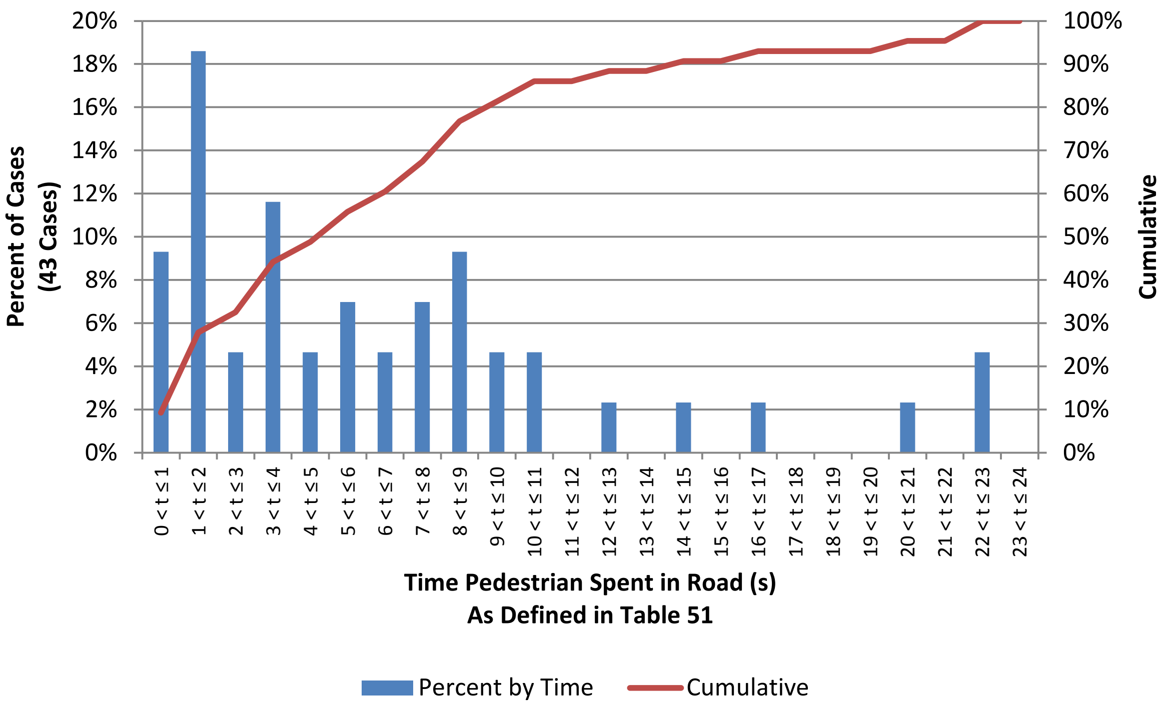

Figure 24: Distribution of Pedestrian Reveal TTC Results from SCI

The histogram of the data shows that 55.8 percent of crashes occur with the pedestrian spending less than 6 s in the road with 46.5 percent of all crashes having the pedestrian spend between 1 and 6 s in the road. A few cases where found to have the pedestrian spending a significant amount of time in the roadway (and potentially in view of the driver and/or PCAM system). Due to the range limitations of the PCAM systems, however, it is difficult to predict that the systems would have any effectiveness above a range/time threshold. For example, it may be unrealistic to assume that a PCAM system may correctly determine a threat as early as 10 seconds before a collision occurs.

On the other hand, although the estimates range beyond 20 s, it is important to note the low proportion of crashes that occur under 1 s TTC (9%). These cases represent the potential cases that may not benefit from a PCAM system using AEB.[47] At low TTC's (e.g. 1 second), the pedestrian has not spent enough time in the road in order for the system to recognize a threat in a timely manner and enact automatic control over the vehicle. This information cannot be directly translated to benefits (or degradation in safety benefits). This information can be interpreted that as a large proportion of the potential target vehicle-pedestrian crashes will benefit from PCAM systems using AEB.

[47] SCI cases have no weight and are not nationally representative of national crash statistics.

Figure 25 shows a distribution of injured pedestrians on the KABCO scale. This information shows that there was a slight bias in the crash selection. Of the 43 crashes, almost half of them involved a pedestrian being fatally struck.

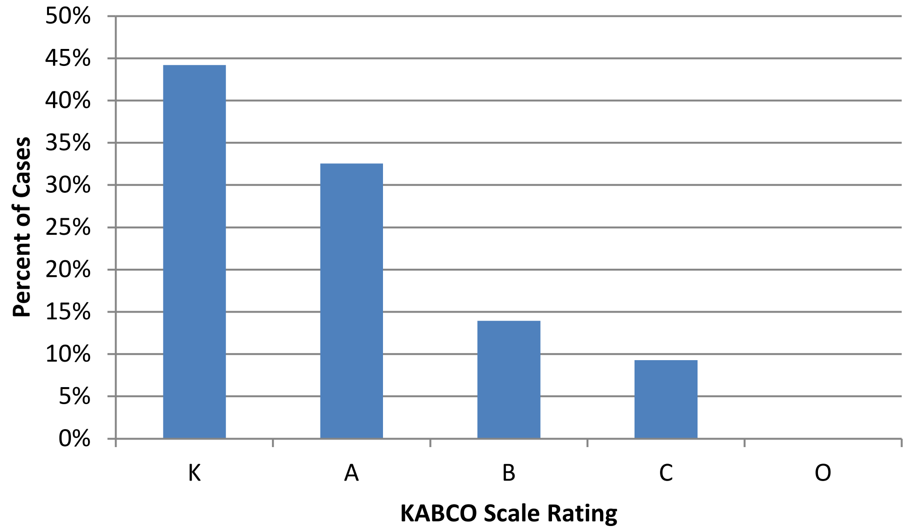

Figure 25: Distribution of Injured Pedestrians on the KABCO Scale

While the SCI crash reconstructions provided a detailed summary of each pedestrian case, there were limitations that prevented it from being further used as part of the crash benefits estimation method, requiring further data acquisition and analysis.

The list of variables collected and their descriptions can be found in Table 51. The data collected was not nationally representative (i.e., no weight and bias towards pedestrian fatalities) and proved to have too wide a range in detailed results to provide major significance. This fact led to using these crashes into the simulation model very difficult. The decision was made to only use this data to justify the appropriateness of PCAM safety systems. The detailed information collected provided information that PCAM systems could apply to historical crashes (e.g., no loss of control, no obstructions, no immediate darting of pedestrians, no major anomalies in the manner of vehicle-pedestrian crashes). External information was used as input into the simulation and supplement the benefits process. Further research or more cases could help provide statistically relevant information, further justification, or more accurate system effectiveness estimates for PCAM systems.

Table 51: List of Variables Collected in the Special Crash Investigation for Vehicle-Pedestrian S1 Crashes

Variable	Description
Year	Year of the crash
State	U.S. State of the crash
# Ped. Involved	Number of pedestrians hit by the vehicle
Ped. Age Group(s)	Age of the first pedestrian hit (years) – if multiple pedestrians, another field
Ped. Injuries	Pedestrian injury level on KABCO scale
Weather	Current weather at the time of the crash
Lighting	Lighting at time of crash (e.g., daylight, dark, dark w/ lighting)
Road Surface Condition	Coefficient of friction on road at the time of crash
Speed Limit	Posted speed limit on the road of the crash (km/h)
Intersection?	Did the crash occur at an intersection? (Y/N)
Roadway Alignment	Road alignment (e.g., straight, curve)
Roadway Grade	Roadway grade
Traffic Control	Traffic control at the crash location (e.g., lights, stop sign, none)
Veh. Pre-Crash Man.	Vehicle maneuver in the pre-crash scenario
Veh. Avoidance Man.	Vehicle attempted avoidance maneuver (e.g., brake, steer, brake and steer)
Travel Lane #	The vehicle travel lane (numbered left to right of driver)
Veh. Speed	Vehicle pre-crash speed (km/h)
Veh. Speed Range	Potential error range on the pre-crash vehicle speed (km/h)
Distance From Ped.	Vehicle distance from pedestrian when the pedestrian entered the road (m)
Veh. Dist. Range	Potential error range on vehicle distance from pedestrian (m)
Driver Vision Obstructed?	Was the driver's vision obstructed?
Vision Obstruction	What obstructed the driver's vision?
Driver Eyes Off Road?	Were the driver's eyes off the road?
What Driver Looked At	What was the driver looking at if the eyes were off the road?
Ped. Man. Pre-Crash	Pedestrian's pre-crash maneuver (e.g., crossing road, walking, jogging, standing)
Ped. Avoidance Man.	Pedestrian avoidance maneuver (e.g., walk, run, yell, none)
Ped. Location Pre-Crash	Pedestrian's pre-crash location
Ped. Speed	Pedestrian's movement speed (km/h)
Ped. Direction	Direction of pedestrian movement (left-right or right-left of vehicle)
Ped. Vision Obscured?	Was the pedestrian's vision obscured?
Ped. Vision Obscured by?	What obscured the pedestrian's vision?
Ped. Impaired?	Was the pedestrian impaired? (include description of impairment)
Ped. Inattention?	Was the pedestrian inattentive?
Ped. Inattentive Because?	Why was the pedestrian inattentive?
Distance Away from Roadway OR **Line of Sight of Car**	Vehicle distance from pedestrian when the pedestrian entered the road or was first visible (m)
Location of impact	Where the impact happened (e.g., roadway, crosswalk)
Travel Lane Location of Impact	The lane of impact (numbered from left to right of vehicle)
Distance From Curb	How far from the curb the impact happened (m)
Before, Middle, After Int.?	Did the impact occur before, inside of, or after the intersection?
Area of Impact on Veh	Part of the vehicle that made contact with pedestrian
Distance Traveled by Veh.	Vehicle distance from pedestrian when the pedestrian entered the road (m)
Time Ped. Spends in Roadway	Time the pedestrian spent in the roadway visible and in path of vehicle (s)
Related Factors/Causal Factors	Any related factors that may have contributed to the crash?
PCAM Warning Helpful?	Would a PCAM warning have been helpful for this crash?
PCAM Automatic Braking Helpful?	Would AEB have been helpful for this crash?
PCAM Automatic Steer Helpful?	Would automatic steering have been helpful for this crash?
Summary	Written description of the entire crash scenario
Scene Diagram and photos	Diagram of crash scene and picture of vehicle (contact area, damage) and scene (location)
GPS Coord.	GPS coordinates of the scene of the crash
Impact Speed	Vehicle impact speed (km/h)
Final Rest v1 and p1	How far the vehicle and pedestrian moved after impact until it came to a stop (m)

APPENDIX C: PCAM TESTING VARIABLES

This section contains a list of all variables that were recorded during PCAM testing, and the descriptions that fit them.

Scenario

- S1- Vehicle traveling straight with pedestrian crossing perpendicular to the vehicle path from right side only.
- S4 - Vehicle traveling straight with pedestrian moving along or stationary in the direct path of the vehicle.

Vehicle

- OEM 1
- OEM 2
- OEM 3

Profile

- Run – Pedestrian is programmed to move at the S1 run speed
    - 8 km/h or 2.2 m/s or 4.9 mph
- Walk – Pedestrian is programmed to move at the S1 walk speed
    - 5 km/h or 1.4 m/s or 3.1 mph

Mannequin

	Shoulder	**Elbow**	**Hip**	**Knee**
NHTSA Adult Articulated	Active	Fixed	Active	Fixed
TASI Adult Articulated	Active	Passive	Active	Active/Passive
4a Adult Articulated	Poseable	Fixed	Active	Passive
4a Child Articulated	Poseable	Fixed	Active	Passive
4a Child Posable	Poseable	Fixed	Poseable	Fixed
TASI Child Articulated	Active	Passive	Active	Passive
Active - Motion at that joint is powered by a servo				
Passive - Motion at that joint is achieved without the use of a servo				
Poseable - Joint can be posed pre-test but does not actively move				
Fixed - Joint has no motion				

Clothing

- Combo 2
    - Blue Pants, Black Shirt
- Combo 3
    - Blue Pants, Gray Shirt

Pedestrian Direction

- From Right
    - The mannequin enters the test lane and crosses the vehicle path from right to left.
- From Left
    - The mannequin enters the test lane and crosses the vehicle path from left to right.
- Away
    - The mannequin faces away from the vehicle.
- Towards
    - The mannequin faces towards the vehicle.

Programmed Impact Location

- The desired subject vehicle (SV)-to-mannequin impact location measure as a percentage of vehicle width.

Vehicle Target Speed

- The test speed of the SV when approaching the mannequin (mph). Entered into the test log by the experimenter.

Pedestrian Offset Distance from Center

- Mannequin start position before entering the immediate path of the SV. This measurement originates from the predefined SV path (lane center), which is also the 50 percent SV-to-mannequin impact location. (m)

Obstruction

- Obstructions are used to evaluate the performance capabilities and limitations of the PCAM sensing technologies. The obstruction is used to block the view of the mannequin target from the SV sensors until the desired reveal time is reached.

Day or Night Test Series

- Day – test conduct was between 9 am to 6 pm

Impact

- Observation entered in test log by experimenter. Was there SV-to-mannequin contact?

Vehicle Speed at TTC of 4.0s

- Measured test speed of the SV at a time-to-collision of 4 seconds. (mph)

Vehicle Distance to Target at TTC of 4.0s

- Measured longitudinal range at a time-to-collision of 4 seconds. (m)

Pre Warning Average Vehicle Speed

- Average measured speed of the SV prior to braking. (mph)

Pedestrian Speed at Lane Entrance

- Measured speed of the mannequin when it enters the vehicle's driving lane. (mph)

Pedestrian Speed at Lane Exit

- Measured speed of the mannequin when it exits the vehicle's driving lane. (mph)

Time to Target at Warning

- Measured longitudinal TTC at the SV's warning. (s)

Vehicle Distance to Target at Warning

- Measured longitudinal distance at the SV's warning. (m)

Pedestrian Distance from Center at Warning

- Measured distance from the mannequin to the center of the lane at the time of warning. (m)

Pedestrian Speed at Warning

- Measured speed of the mannequin at the time of warning. (mph)

Time to Target at AEB

- Measured longitudinal TTC at the SV's AEB activation. (s)

Vehicle Distance to Target at AEB

- Measured longitudinal distance at the SV's AEB activation. (m)

Pedestrian Distance from Center at AEB

- Measured distance from the mannequin to the center of the lane at the time of AEB activation. (m)

Pedestrian Speed at AEB

- Measured speed of the mannequin at the time of AEB activation. (mph)

Pre Braking Speed Average

- Average measured speed of the SV prior to braking. (mph)

Approximate Impact Speed

- Measured speed of the SV at longitudinal range = 0. (mph)

Relative Impact Speed

- The impact speed of the SV relative to the speed of the mannequin in an S4 scenario. (mph)

Minimum Range

- SV minimum longitudinal range at the end of test conduct. (m)

Pre Pedestrian Motion Average Vehicle Speed

- Average measured speed of the SV before the pedestrian begins moving. (mph)

Speed Reduction

- SV pre braking speed average – SV speed at longitudinal range = 0. (mph)

Percent Speed Reduction Relative to Speed at Pedestrian Motion

- (SV speed at minimum range / Pre-Pedestrian-Motion SV speed) * 100. (%)

Average AEB Initiated Deceleration Rate

- (SV speed at AEB onset – SV speed at minimum range) / time between events. (m/s^2)

Max AEB Initiated Deceleration Rate

- Maximum SV deceleration rate between AEB onset and minimum range. (m/s^2)

APPENDIX D: TEST TRACK DATA RESULTS

OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)	OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)
1	12	N	12	0.7	0.5	6.8	4.9	S1,Adult,Run,Light,No	1	7	Y	21	0.6	0.5	5.8	4.9	S1,Adult,Run,Light,No
1	10	N	10	0.8	0.6	6.8	4.9	S1,Adult,Run,Light,No	1	7	Y	15	0.5	0.4	5.6	4.9	S1,Adult,Run,Light,No
1	12	N	12	0.8	0.7	5.9	4.9	S1,Adult,Run,Light,No	1	0	Y	9	0.1	0.0	0.0	5.0	S1,Adult,Run,Light,No
1	15	N	15	0.9	0.8	4.1	5.0	S1,Adult,Run,Light,No	1	3	Y	25	0.3	0.3	4.3	5.0	S1,Adult,Run,Light,No
1	13	N	13	0.8	0.7	6.8	4.9	S1,Adult,Run,Light,No	1	0	Y	19	0.1	0.0	0.0	4.9	S1,Adult,Run,Light,No
1	19	N	19	0.8	0.6	6.6	4.9	S1,Adult,Run,Light,No	1	0	Y	13	0.1	0.0	0.0	5.0	S1,Adult,Run,Light,No
1	16	N	16	0.9	0.8	6.8	4.9	S1,Adult,Run,Light,No	1	0	Y	13	0.1	0.0	0.0	4.9	S1,Adult,Run,Light,No
1	22	N	21	0.8	0.7	7.3	4.9	S1,Adult,Run,Light,No	1	0	Y	12	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
1	22	N	22	0.9	0.8	7.6	4.9	S1,Adult,Run,Light,No	1	10	Y	23	0.6	0.6	6.0	4.9	S1,Adult,Run,Light,No
1	16	N	16	0.7	0.6	6.2	5.0	S1,Adult,Run,Light,No	1	0	Y	10	0.0	0.0	0.0	5.0	S1,Adult,Run,Light,No
1	13	N	12	0.6	0.5	6.6	4.9	S1,Adult,Run,Light,No	1	0	Y	10	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
1	25	N	24	0.9	0.8	6.7	4.9	S1,Adult,Run,Light,No	1	0	Y	12	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
1	12	N	12	0.5	0.4	6.3	4.9	S1,Adult,Run,Light,No	1	0	Y	12	0.0	0.0	0.0	5.0	S1,Adult,Run,Light,No
1	12	N	12	0.7	0.6	6.7	4.9	S1,Adult,Run,Light,No	1	0	Y	10	0.0	0.0	0.0	0.0	S1,Adult,Run,Light,No
1	13	N	13	0.8	0.7	6.7	5.0	S1,Adult,Run,Light,No	1	0	Y	10	0.0	0.0	0.0	0.0	S1,Adult,Run,Light,No
1	15	N	15	0.6	0.5	6.5	5.0	S1,Adult,Run,Light,No	1	0	Y	13	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
1	22	N	22	0.9	0.8	7.0	5.0	S1,Adult,Run,Light,No	1	0	Y	16	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
1	16	N	16	0.7	0.6	7.0	4.9	S1,Adult,Run,Light,No	1	0	Y	10	0.0	0.0	0.0	4.8	S1,Adult,Run,Light,No
1	10	N	10	0.4	0.3	6.9	5.0	S1,Adult,Run,Light,No	1	0	Y	10	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
1	21	N	21	0.8	0.8	6.9	5.1	S1,Adult,Run,Light,No	1	0	Y	9	0.0	0.0	0.0	5.0	S1,Adult,Run,Light,No
1	18	N	19	0.7	0.6	6.3	4.9	S1,Adult,Run,Light,No	1	0	Y	16	0.0	0.0	0.0	5.0	S1,Adult,Run,Light,No
1	13	N	13	0.6	0.5	6.7	4.9	S1,Adult,Run,Light,No	1	0	Y	22	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
1	22	N	22	0.8	0.7	7.1	4.9	S1,Adult,Run,Light,No	1	0	Y	10	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
1	20	N	20	0.7	0.7	6.7	4.9	S1,Adult,Run,Light,No	1	0	Y	13	0.0	0.0	0.0	5.0	S1,Adult,Run,Light,No
1	22	N	22	0.9	0.9	7.8	4.9	S1,Adult,Run,Light,No	1	0	Y	10	0.0	0.0	0.0	4.8	S1,Adult,Run,Light,No
1	19	N	19	0.7	0.7	5.5	4.9	S1,Adult,Run,Light,No	1	0	Y	9	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
1	19	N	19	0.7	0.6	7.1	4.9	S1,Adult,Run,Light,No	1	0	Y	10	0.0	0.0	0.0	5.0	S1,Adult,Run,Light,No
1	16	N	16	0.8	0.7	5.2	5.0	S1,Adult,Run,Light,No	1	0	Y	13	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
1	16	N	16	0.8	0.7	6.7	4.9	S1,Adult,Run,Light,No	1	0	Y	13	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
1	0	Y	13	0.2	0.0	0.0	4.9	S1,Adult,Run,Light,No	1	0	Y	10	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
1	13	Y	25	0.8	0.7	6.4	4.9	S1,Adult,Run,Light,No	1	0	Y	10	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
1	7	Y	19	0.5	0.4	6.2	5.0	S1,Adult,Run,Light,No	1	0	Y	12	0.0	0.0	0.0	5.0	S1,Adult,Run,Light,No
1	11	Y	18	0.6	0.5	6.8	4.9	S1,Adult,Run,Light,No	1	0	Y	10	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
1	6	Y	12	0.4	0.3	5.7	4.9	S1,Adult,Run,Light,No	1	0	Y	10	0.0	0.0	0.0	4.8	S1,Adult,Run,Light,No
1	8	Y	15	0.7	0.6	5.3	5.0	S1,Adult,Run,Light,No	1	0	Y	13	0.0	0.0	0.0	4.8	S1,Adult,Run,Light,No
1	13	Y	25	0.7	0.6	6.8	4.9	S1,Adult,Run,Light,No	1	0	Y	25	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
1	5	Y	12	0.4	0.3	5.8	4.9	S1,Adult,Run,Light,No	1	0	Y	10	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
1	6	Y	22	0.5	0.4	5.8	4.9	S1,Adult,Run,Light,No	1	0	Y	10	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
1	11	Y	25	0.7	0.6	6.8	4.9	S1,Adult,Run,Light,No	1	0	Y	12	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
1	2	Y	10	0.3	0.2	4.2	5.0	S1,Adult,Run,Light,No	1	0	Y	10	0.0	0.0	0.0	5.0	S1,Adult,Run,Light,No
1	13	Y	22	0.7	0.6	7.0	5.0	S1,Adult,Run,Light,No	1	0	Y	9	0.0	0.0	0.0	5.0	S1,Adult,Run,Light,No
1	12	Y	25	0.7	0.6	7.0	4.9	S1,Adult,Run,Light,No	1	0	Y	13	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
1	10	Y	19	0.6	0.5	6.6	5.0	S1,Adult,Run,Light,No	1	0	Y	12	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
1	4	Y	13	0.4	0.3	5.3	4.9	S1,Adult,Run,Light,No	1	0	Y	10	0.0	0.0	0.0	0.0	S1,Adult,Run,Light,No
1	13	Y	19	0.7	0.6	6.9	4.9	S1,Adult,Run,Light,No	1	0	Y	9	0.0	0.0	0.0	4.8	S1,Adult,Run,Light,No
1	6	Y	16	0.4	0.3	5.9	5.0	S1,Adult,Run,Light,No	1	0	Y	12	0.0	0.0	0.0	0.0	S1,Adult,Run,Light,No
1	9	Y	19	0.6	0.5	6.8	4.9	S1,Adult,Run,Light,No	2	10	N	16	1.0	0.8	6.8	4.9	S1,Adult,Run,Light,No
1	1	Y	12	0.2	0.1	3.1	4.9	S1,Adult,Run,Light,No	2	8	N	13	0.9	0.7	6.1	4.9	S1,Adult,Run,Light,No
1	9	Y	18	0.6	0.5	6.4	4.9	S1,Adult,Run,Light,No	2	12	N	19	1.2	1.0	5.7	5.0	S1,Adult,Run,Light,No
1	6	Y	22	0.5	0.4	5.9	5.0	S1,Adult,Run,Light,No	2	16	N	25	1.1	0.9	6.9	4.9	S1,Adult,Run,Light,No

OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)	OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)
2	10	N	16	0.9	0.7	6.8	4.9	S1,Adult,Run,Light,No	2	10	Y	16	0.8	0.6	6.9	4.9	S1,Adult,Run,Light,No
2	8	N	13	1.0	0.9	5.8	5.1	S1,Adult,Run,Light,No	2	11	Y	22	1.0	0.8	7.0	4.9	S1,Adult,Run,Light,No
2	8	N	13	1.0	0.8	5.9	4.9	S1,Adult,Run,Light,No	2	10	Y	19	0.9	0.7	6.7	4.8	S1,Adult,Run,Light,No
2	10	N	16	1.1	0.9	6.1	5.1	S1,Adult,Run,Light,No	2	8	Y	28	0.9	0.7	6.5	4.9	S1,Adult,Run,Light,No
2	8	N	13	1.0	0.8	5.7	5.0	S1,Adult,Run,Light,No	2	2	Y	9	0.5	0.3	4.2	4.9	S1,Adult,Run,Light,No
2	12	N	19	1.0	0.8	7.0	4.9	S1,Adult,Run,Light,No	2	7	Y	25	0.8	0.7	6.2	4.9	S1,Adult,Run,Light,No
2	10	N	15	0.8	0.6	6.9	4.9	S1,Adult,Run,Light,No	2	6	Y	25	0.9	0.7	5.9	4.9	S1,Adult,Run,Light,No
2	16	N	25	1.1	0.9	6.8	5.1	S1,Adult,Run,Light,No	2	6	Y	16	0.7	0.6	5.3	4.9	S1,Adult,Run,Light,No
2	14	N	22	1.1	0.9	6.9	5.1	S1,Adult,Run,Light,No	2	6	Y	22	0.9	0.7	6.4	4.9	S1,Adult,Run,Light,No
2	17	N	28	1.2	1.0	7.3	5.0	S1,Adult,Run,Light,No	2	6	Y	28	0.8	0.6	6.4	4.9	S1,Adult,Run,Light,No
2	17	N	28	1.1	1.0	6.8	5.0	S1,Adult,Run,Light,No	2	2	Y	10	0.5	0.3	4.7	4.9	S1,Adult,Run,Light,No
2	12	N	19	1.0	0.8	6.8	4.9	S1,Adult,Run,Light,No	2	10	Y	23	0.9	0.8	6.6	4.9	S1,Adult,Run,Light,No
2	16	N	25	1.1	1.0	7.3	4.9	S1,Adult,Run,Light,No	2	1	Y	13	0.4	0.2	2.3	4.9	S1,Adult,Run,Light,No
2	10	N	16	1.0	0.9	6.2	4.9	S1,Adult,Run,Light,No	2	7	Y	31	0.8	0.7	6.8	5.0	S1,Adult,Run,Light,No
2	10	N	15	1.0	0.8	6.1	5.2	S1,Adult,Run,Light,No	2	1	Y	12	0.4	0.3	2.2	5.0	S1,Adult,Run,Light,No
2	8	N	13	1.0	0.8	5.5	5.0	S1,Adult,Run,Light,No	2	7	Y	31	0.8	0.7	6.6	4.9	S1,Adult,Run,Light,No
2	12	N	19	0.9	0.7	6.8	4.9	S1,Adult,Run,Light,No	2	8	Y	25	0.8	0.6	6.9	5.0	S1,Adult,Run,Light,No
2	8	N	12	0.7	0.6	6.6	5.7	S1,Adult,Run,Light,No	2	0	Y	9	0.1	0.0	0.0	4.9	S1,Adult,Run,Light,No
2	14	N	22	1.1	0.9	6.9	5.0	S1,Adult,Run,Light,No	2	0	Y	10	0.1	0.1	0.9	5.0	S1,Adult,Run,Light,No
2	16	N	25	1.1	0.9	6.8	4.9	S1,Adult,Run,Light,No	2	1	Y	10	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
2	16	N	25	1.1	0.9	7.4	5.0	S1,Adult,Run,Light,No	2	0	Y	10	0.0	0.0	0.0	5.0	S1,Adult,Run,Light,No
2	16	N	25	1.1	0.9	7.3	4.9	S1,Adult,Run,Light,No	2	0	Y	13	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
2	10	N	16	0.8	0.7	7.2	4.9	S1,Adult,Run,Light,No	2	0	Y	12	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
2	13	N	22	1.0	0.9	7.0	4.9	S1,Adult,Run,Light,No	2	0	Y	10	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
2	12	N	19	1.0	0.8	7.2	4.9	S1,Adult,Run,Light,No	2	0	Y	13	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
2	12	N	19	1.1	0.9	6.3	4.9	S1,Adult,Run,Light,No	2	0	Y	12	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
2	8	N	12	1.0	0.9	5.7	4.9	S1,Adult,Run,Light,No	2	0	Y	10	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
2	8	N	13	0.7	0.6	6.3	4.9	S1,Adult,Run,Light,No	2	0	Y	13	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
2	8	N	13	0.7	0.5	7.0	4.9	S1,Adult,Run,Light,No	2	0	Y	10	0.0	0.0	0.0	5.3	S1,Adult,Run,Light,No
2	8	N	13	0.9	0.7	5.6	4.9	S1,Adult,Run,Light,No	2	0	Y	10	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
2	12	N	19	0.8	0.6	6.9	5.0	S1,Adult,Run,Light,No	2	0	Y	9	0.0	0.0	0.0	5.4	S1,Adult,Run,Light,No
2	10	N	16	0.8	0.7	7.0	4.9	S1,Adult,Run,Light,No	2	0	Y	9	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
2	14	N	22	1.2	1.0	6.7	5.0	S1,Adult,Run,Light,No	2	0	Y	12	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
2	12	N	19	0.9	0.7	6.7	4.9	S1,Adult,Run,Light,No	2	0	Y	10	0.0	0.0	0.0	5.0	S1,Adult,Run,Light,No
2	14	N	22	0.9	0.7	7.2	4.9	S1,Adult,Run,Light,No	2	0	Y	10	0.0	0.0	0.0	5.1	S1,Adult,Run,Light,No
2	17	N	28	1.2	1.0	6.8	4.9	S1,Adult,Run,Light,No	2	0	Y	12	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
2	12	N	19	0.9	0.7	7.0	5.0	S1,Adult,Run,Light,No	2	0	Y	12	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
2	14	N	22	1.2	1.1	5.6	4.9	S1,Adult,Run,Light,No	2	0	Y	13	0.0	0.0	0.0	5.1	S1,Adult,Run,Light,No
2	6	N	10	0.5	0.3	5.0	4.9	S1,Adult,Run,Light,No	2	0	Y	10	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
2	12	N	19	0.9	0.7	7.2	5.0	S1,Adult,Run,Light,No	2	0	Y	10	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
2	14	N	22	1.0	0.8	7.4	4.9	S1,Adult,Run,Light,No	2	0	Y	10	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
2	17	N	28	1.3	1.1	6.2	4.9	S1,Adult,Run,Light,No	2	0	Y	13	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
2	14	N	22	1.1	0.9	6.1	4.9	S1,Adult,Run,Light,No	2	0	Y	10	0.0	0.0	0.0	5.0	S1,Adult,Run,Light,No
2	15	N	25	0.9	0.7	7.3	4.9	S1,Adult,Run,Light,No	2	0	Y	10	0.0	0.0	0.0	5.0	S1,Adult,Run,Light,No
2	14	N	22	1.0	0.9	6.3	4.9	S1,Adult,Run,Light,No	2	0	Y	12	0.0	0.0	0.0	5.0	S1,Adult,Run,Light,No
2	12	N	19	0.8	0.7	7.1	4.9	S1,Adult,Run,Light,No	2	0	Y	9	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
2	0	Y	16	0.5	0.0	0.0	4.9	S1,Adult,Run,Light,No	2	0	Y	9	0.0	0.0	0.0	4.8	S1,Adult,Run,Light,No
2	0	Y	15	0.3	0.0	0.0	4.9	S1,Adult,Run,Light,No	2	0	Y	12	0.0	0.0	0.0	4.9	S1,Adult,Run,Light,No
2	0	Y	9	0.3	0.0	0.0	4.9	S1,Adult,Run,Light,No	2	0	Y	10	0.0	0.0	0.0	5.0	S1,Adult,Run,Light,No
2	0	Y	13	0.3	0.0	0.0	4.9	S1,Adult,Run,Light,No	2	0	Y	12	0.0	0.0	0.0	4.8	S1,Adult,Run,Light,No

OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)	OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)
1	31	N	31	1.8	1.2	7.2	3.1	S1,Adult,Walk,Light,No	1	16	N	16	1.0	0.7	7.4	3.2	S1,Adult,Walk,Light,No
1	16	N	16	1.5	0.9	6.3	3.1	S1,Adult,Walk,Light,No	1	13	N	13	0.9	0.7	6.8	3.1	S1,Adult,Walk,Light,No
1	13	N	13	1.2	0.6	6.5	3.0	S1,Adult,Walk,Light,No	1	22	N	22	1.3	1.0	7.4	3.1	S1,Adult,Walk,Light,No
1	13	N	13	1.3	0.7	7.0	3.1	S1,Adult,Walk,Light,No	1	28	N	27	1.1	0.9	7.8	3.1	S1,Adult,Walk,Light,No
1	9	N	10	1.2	0.6	6.8	3.1	S1,Adult,Walk,Light,No	1	25	N	25	1.4	1.1	7.0	3.1	S1,Adult,Walk,Light,No
1	27	N	27	1.7	1.1	6.0	3.1	S1,Adult,Walk,Light,No	1	31	N	31	1.4	1.2	8.5	3.0	S1,Adult,Walk,Light,No
1	16	N	16	1.4	0.9	7.0	3.2	S1,Adult,Walk,Light,No	1	13	N	13	0.9	0.7	6.3	3.2	S1,Adult,Walk,Light,No
1	19	N	19	1.5	1.0	7.1	3.2	S1,Adult,Walk,Light,No	1	28	N	28	1.3	1.1	7.5	3.1	S1,Adult,Walk,Light,No
1	19	N	19	1.4	0.9	7.4	3.1	S1,Adult,Walk,Light,No	1	22	N	22	1.3	1.1	7.2	3.1	S1,Adult,Walk,Light,No
1	19	N	18	1.5	1.0	6.8	3.1	S1,Adult,Walk,Light,No	1	15	N	15	1.0	0.8	6.9	3.0	S1,Adult,Walk,Light,No
1	22	N	22	1.5	1.0	7.5	3.0	S1,Adult,Walk,Light,No	1	18	N	18	1.0	0.8	7.2	3.1	S1,Adult,Walk,Light,No
1	19	N	19	1.5	1.0	6.9	3.1	S1,Adult,Walk,Light,No	1	28	N	28	1.3	1.2	8.0	3.1	S1,Adult,Walk,Light,No
1	10	N	10	1.1	0.6	5.9	3.1	S1,Adult,Walk,Light,No	1	16	N	16	1.2	1.0	6.2	3.1	S1,Adult,Walk,Light,No
1	10	N	10	1.0	0.6	6.5	3.2	S1,Adult,Walk,Light,No	1	12	N	12	0.8	0.7	6.7	3.1	S1,Adult,Walk,Light,No
1	10	N	10	1.1	0.6	6.9	3.1	S1,Adult,Walk,Light,No	1	25	N	25	1.3	1.2	7.5	3.1	S1,Adult,Walk,Light,No
1	31	N	31	1.6	1.1	8.1	3.1	S1,Adult,Walk,Light,No	1	12	N	12	0.8	0.6	5.5	3.1	S1,Adult,Walk,Light,No
1	13	N	13	1.1	0.6	6.2	3.1	S1,Adult,Walk,Light,No	1	37	N	37	1.3	1.1	8.7	3.1	S1,Adult,Walk,Light,No
1	12	N	12	1.2	0.7	5.7	3.1	S1,Adult,Walk,Light,No	1	34	N	34	1.3	1.1	8.9	3.2	S1,Adult,Walk,Light,No
1	16	N	16	1.2	0.7	7.4	3.1	S1,Adult,Walk,Light,No	1	37	N	37	1.3	1.1	8.3	3.2	S1,Adult,Walk,Light,No
1	37	N	37	1.5	1.1	8.5	3.2	S1,Adult,Walk,Light,No	1	25	N	25	1.2	1.0	8.1	3.1	S1,Adult,Walk,Light,No
1	22	N	22	1.5	1.0	7.5	3.1	S1,Adult,Walk,Light,No	1	25	N	25	1.1	1.0	7.9	3.1	S1,Adult,Walk,Light,No
1	10	N	10	1.1	0.6	4.8	3.1	S1,Adult,Walk,Light,No	1	22	N	22	0.9	0.8	7.9	3.1	S1,Adult,Walk,Light,No
1	13	N	12	1.3	0.8	6.4	3.1	S1,Adult,Walk,Light,No	1	33	N	34	1.2	1.1	8.7	3.2	S1,Adult,Walk,Light,No
1	16	N	15	1.2	0.8	6.2	3.1	S1,Adult,Walk,Light,No	1	28	N	28	1.1	0.9	8.4	3.1	S1,Adult,Walk,Light,No
1	34	N	34	1.5	1.1	8.1	3.1	S1,Adult,Walk,Light,No	1	22	N	22	0.9	0.8	7.2	3.1	S1,Adult,Walk,Light,No
1	16	N	15	1.3	0.8	7.2	3.1	S1,Adult,Walk,Light,No	1	15	N	15	0.9	0.8	6.7	3.1	S1,Adult,Walk,Light,No
1	16	N	16	1.2	0.8	6.0	3.1	S1,Adult,Walk,Light,No	1	22	N	21	1.2	1.1	7.2	3.1	S1,Adult,Walk,Light,No
1	19	N	19	1.2	0.8	7.1	3.1	S1,Adult,Walk,Light,No	1	25	N	25	1.0	0.9	7.7	3.1	S1,Adult,Walk,Light,No
1	13	N	13	1.0	0.6	6.8	3.1	S1,Adult,Walk,Light,No	1	34	N	34	1.1	1.0	8.9	3.2	S1,Adult,Walk,Light,No
1	34	N	34	1.5	1.1	8.1	3.1	S1,Adult,Walk,Light,No	1	22	N	22	1.1	1.0	8.1	3.2	S1,Adult,Walk,Light,No
1	16	N	15	1.2	0.8	7.2	3.1	S1,Adult,Walk,Light,No	1	31	N	31	1.1	1.0	8.6	3.1	S1,Adult,Walk,Light,No
1	21	N	21	1.4	1.0	7.1	3.1	S1,Adult,Walk,Light,No	1	19	N	19	1.0	1.0	6.9	3.1	S1,Adult,Walk,Light,No
1	18	N	18	1.3	0.9	7.2	3.0	S1,Adult,Walk,Light,No	1	25	N	25	1.1	1.0	8.1	3.1	S1,Adult,Walk,Light,No
1	12	N	12	1.1	0.7	6.5	3.1	S1,Adult,Walk,Light,No	1	28	N	28	1.1	1.1	8.6	3.1	S1,Adult,Walk,Light,No
1	31	N	31	1.5	1.1	8.6	3.1	S1,Adult,Walk,Light,No	1	22	N	22	0.8	0.8	7.4	3.1	S1,Adult,Walk,Light,No
1	19	N	19	1.4	1.0	7.0	3.3	S1,Adult,Walk,Light,No	1	19	N	18	1.0	0.9	7.4	3.1	S1,Adult,Walk,Light,No
1	25	N	25	1.5	1.1	7.2	3.2	S1,Adult,Walk,Light,No	1	31	N	31	1.1	1.1	8.6	3.1	S1,Adult,Walk,Light,No
1	25	N	25	1.4	1.1	7.6	3.0	S1,Adult,Walk,Light,No	1	34	N	34	1.2	1.1	7.5	3.1	S1,Adult,Walk,Light,No
1	22	N	22	1.3	1.0	6.0	3.1	S1,Adult,Walk,Light,No	1	27	N	28	1.1	1.0	8.3	3.1	S1,Adult,Walk,Light,No
1	16	N	16	1.2	0.9	6.6	3.1	S1,Adult,Walk,Light,No	1	28	N	28	1.0	0.9	8.5	3.1	S1,Adult,Walk,Light,No
1	13	N	13	1.0	0.7	7.3	3.1	S1,Adult,Walk,Light,No	1	28	N	28	1.1	1.0	8.5	3.1	S1,Adult,Walk,Light,No
1	16	N	16	1.0	0.7	6.8	3.0	S1,Adult,Walk,Light,No	1	27	N	27	1.1	1.1	6.5	3.1	S1,Adult,Walk,Light,No
1	31	N	31	1.4	1.1	7.9	3.1	S1,Adult,Walk,Light,No	1	1	Y	10	1.2	0.2	3.3	3.1	S1,Adult,Walk,Light,No
1	34	N	34	1.4	1.1	7.2	3.1	S1,Adult,Walk,Light,No	1	1	Y	13	1.6	0.7	1.4	3.2	S1,Adult,Walk,Light,No
1	28	N	28	1.4	1.1	7.2	3.2	S1,Adult,Walk,Light,No	1	3	Y	12	1.4	0.6	2.3	3.1	S1,Adult,Walk,Light,No
1	37	N	37	1.4	1.1	8.8	3.1	S1,Adult,Walk,Light,No	1	3	Y	19	0.9	0.1	2.9	3.1	S1,Adult,Walk,Light,No
1	28	N	28	1.3	1.1	7.7	3.1	S1,Adult,Walk,Light,No	1	0	Y	9	0.5	0.0	0.0	3.1	S1,Adult,Walk,Light,No
1	22	N	22	1.3	1.1	7.0	3.1	S1,Adult,Walk,Light,No	1	17	Y	34	1.2	0.8	7.5	3.0	S1,Adult,Walk,Light,No
1	25	N	24	1.4	1.1	7.5	3.1	S1,Adult,Walk,Light,No	1	0	Y	10	0.3	0.0	0.0	3.1	S1,Adult,Walk,Light,No
1	16	N	16	1.1	0.8	6.9	3.1	S1,Adult,Walk,Light,No	1	0	Y	9	0.3	0.0	0.0	3.1	S1,Adult,Walk,Light,No

OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)	OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)
1	10	Y	15	0.6	0.5	6.8	3.1	S1,Adult,Walk,Light,No	2	6	N	9	1.0	0.8	5.1	3.1	S1,Adult,Walk,Light,No
1	1	Y	18	0.3	0.2	3.8	3.1	S1,Adult,Walk,Light,No	2	23	N	37	1.5	1.3	7.4	3.1	S1,Adult,Walk,Light,No
1	7	Y	16	0.8	0.7	3.0	3.1	S1,Adult,Walk,Light,No	2	8	N	13	1.1	0.9	5.3	3.1	S1,Adult,Walk,Light,No
1	21	Y	31	0.9	0.8	8.1	3.1	S1,Adult,Walk,Light,No	2	10	N	16	1.2	1.0	5.2	3.1	S1,Adult,Walk,Light,No
1	14	Y	31	0.8	0.7	7.5	3.1	S1,Adult,Walk,Light,No	2	21	N	34	1.4	1.2	7.4	3.1	S1,Adult,Walk,Light,No
1	2	Y	25	0.3	0.2	4.3	3.2	S1,Adult,Walk,Light,No	2	23	N	38	1.5	1.3	7.2	3.1	S1,Adult,Walk,Light,No
1	18	Y	19	0.8	0.7	7.1	3.1	S1,Adult,Walk,Light,No	2	6	N	10	1.1	0.9	4.4	3.2	S1,Adult,Walk,Light,No
1	19	Y	35	0.9	0.8	8.0	3.1	S1,Adult,Walk,Light,No	2	6	N	9	0.9	0.7	4.6	3.1	S1,Adult,Walk,Light,No
1	0	Y	34	0.1	0.0	0.0	3.1	S1,Adult,Walk,Light,No	2	6	N	10	1.0	0.8	4.3	3.1	S1,Adult,Walk,Light,No
1	0	Y	16	0.0	0.0	0.0	3.0	S1,Adult,Walk,Light,No	2	11	N	18	1.3	1.1	5.4	3.1	S1,Adult,Walk,Light,No
1	0	Y	10	0.0	0.0	0.0	3.3	S1,Adult,Walk,Light,No	2	12	N	19	1.4	1.2	5.0	3.3	S1,Adult,Walk,Light,No
1	15	Y	31	0.9	1.0	5.7	3.0	S1,Adult,Walk,Light,No	2	23	N	38	1.6	1.4	6.9	3.1	S1,Adult,Walk,Light,No
2	19	N	31	1.6	1.3	5.8	3.1	S1,Adult,Walk,Light,No	2	8	N	13	1.0	0.8	5.7	3.0	S1,Adult,Walk,Light,No
2	23	N	37	1.6	1.3	7.2	3.1	S1,Adult,Walk,Light,No	2	9	N	15	1.3	1.1	5.0	3.1	S1,Adult,Walk,Light,No
2	19	N	31	1.5	1.3	6.0	3.1	S1,Adult,Walk,Light,No	2	8	N	13	1.2	1.0	4.4	3.1	S1,Adult,Walk,Light,No
2	17	N	28	1.5	1.2	5.7	3.2	S1,Adult,Walk,Light,No	2	6	N	10	0.9	0.7	4.8	3.1	S1,Adult,Walk,Light,No
2	19	N	31	1.6	1.3	6.1	3.1	S1,Adult,Walk,Light,No	2	6	N	9	1.0	0.8	4.4	3.1	S1,Adult,Walk,Light,No
2	12	N	19	1.4	1.2	5.2	3.1	S1,Adult,Walk,Light,No	2	6	N	10	1.0	0.8	4.6	3.1	S1,Adult,Walk,Light,No
2	8	N	13	1.1	0.8	5.5	3.1	S1,Adult,Walk,Light,No	2	8	N	13	1.1	0.9	5.3	3.1	S1,Adult,Walk,Light,No
2	8	N	12	1.0	0.8	5.5	3.1	S1,Adult,Walk,Light,No	2	6	N	9	0.7	0.5	5.3	3.1	S1,Adult,Walk,Light,No
2	15	N	25	1.5	1.3	4.9	3.1	S1,Adult,Walk,Light,No	2	15	N	24	1.2	1.0	7.0	3.1	S1,Adult,Walk,Light,No
2	13	N	22	1.5	1.2	5.2	3.1	S1,Adult,Walk,Light,No	2	19	N	31	1.6	1.4	5.6	3.1	S1,Adult,Walk,Light,No
2	6	N	9	1.0	0.8	4.0	3.1	S1,Adult,Walk,Light,No	2	21	N	34	1.4	1.2	7.1	3.1	S1,Adult,Walk,Light,No
2	15	N	25	1.6	1.4	4.8	3.1	S1,Adult,Walk,Light,No	2	18	N	28	1.5	1.3	5.4	3.1	S1,Adult,Walk,Light,No
2	11	N	19	0.9	0.7	7.1	3.1	S1,Adult,Walk,Light,No	2	17	N	28	1.5	1.3	5.6	3.1	S1,Adult,Walk,Light,No
2	9	N	15	1.2	0.9	5.6	3.1	S1,Adult,Walk,Light,No	2	15	N	25	1.5	1.3	5.0	3.1	S1,Adult,Walk,Light,No
2	15	N	25	1.5	1.3	5.7	3.1	S1,Adult,Walk,Light,No	2	8	N	13	0.9	0.7	6.1	3.1	S1,Adult,Walk,Light,No
2	10	N	16	1.2	1.0	5.2	3.0	S1,Adult,Walk,Light,No	2	12	N	19	1.2	1.1	5.8	3.2	S1,Adult,Walk,Light,No
2	6	N	9	1.0	0.8	4.2	3.1	S1,Adult,Walk,Light,No	2	10	N	16	1.3	1.1	5.2	3.1	S1,Adult,Walk,Light,No
2	6	N	9	0.9	0.7	4.7	3.1	S1,Adult,Walk,Light,No	2	21	N	34	1.4	1.3	7.3	3.1	S1,Adult,Walk,Light,No
2	8	N	12	0.9	0.7	6.0	3.1	S1,Adult,Walk,Light,No	2	8	N	12	1.1	0.9	5.5	3.1	S1,Adult,Walk,Light,No
2	19	N	30	1.5	1.2	6.8	3.1	S1,Adult,Walk,Light,No	2	10	N	16	0.9	0.7	6.5	3.1	S1,Adult,Walk,Light,No
2	19	N	31	1.5	1.3	6.4	3.2	S1,Adult,Walk,Light,No	2	16	N	25	1.5	1.3	5.0	3.1	S1,Adult,Walk,Light,No
2	10	N	15	1.3	1.0	5.1	3.1	S1,Adult,Walk,Light,No	2	6	N	9	0.8	0.6	5.3	3.1	S1,Adult,Walk,Light,No
2	19	N	31	1.5	1.2	6.8	3.0	S1,Adult,Walk,Light,No	2	10	N	16	1.2	1.0	5.3	3.1	S1,Adult,Walk,Light,No
2	6	N	9	0.9	0.6	4.9	3.1	S1,Adult,Walk,Light,No	2	15	N	25	1.6	1.4	4.9	3.1	S1,Adult,Walk,Light,No
2	18	N	28	1.6	1.4	5.5	3.1	S1,Adult,Walk,Light,No	2	8	N	12	1.2	1.0	4.3	3.1	S1,Adult,Walk,Light,No
2	8	N	12	1.0	0.8	4.5	3.1	S1,Adult,Walk,Light,No	2	15	N	25	1.4	1.2	6.0	3.1	S1,Adult,Walk,Light,No
2	23	N	37	1.6	1.4	7.1	3.1	S1,Adult,Walk,Light,No	2	23	N	37	1.4	1.2	7.6	3.1	S1,Adult,Walk,Light,No
2	8	N	12	1.1	0.8	4.7	3.1	S1,Adult,Walk,Light,No	2	16	N	25	1.5	1.3	5.0	3.1	S1,Adult,Walk,Light,No
2	7	N	12	1.1	0.9	4.9	3.1	S1,Adult,Walk,Light,No	2	23	N	37	1.6	1.4	6.8	3.1	S1,Adult,Walk,Light,No
2	19	N	31	1.5	1.3	6.3	3.1	S1,Adult,Walk,Light,No	2	14	N	22	1.3	1.1	5.7	3.1	S1,Adult,Walk,Light,No
2	12	N	19	1.3	1.0	6.0	3.1	S1,Adult,Walk,Light,No	2	14	N	22	1.4	1.3	4.8	3.1	S1,Adult,Walk,Light,No
2	12	N	19	1.3	1.1	5.6	3.1	S1,Adult,Walk,Light,No	2	19	N	31	1.6	1.4	5.4	3.0	S1,Adult,Walk,Light,No
2	17	N	28	1.5	1.3	5.1	3.1	S1,Adult,Walk,Light,No	2	10	N	16	1.2	1.0	5.5	3.1	S1,Adult,Walk,Light,No
2	20	N	31	1.6	1.4	5.6	3.1	S1,Adult,Walk,Light,No	2	21	N	34	1.5	1.3	6.9	3.1	S1,Adult,Walk,Light,No
2	23	N	37	1.6	1.4	6.7	3.1	S1,Adult,Walk,Light,No	2	19	N	31	1.4	1.2	7.0	3.1	S1,Adult,Walk,Light,No
2	18	N	28	1.5	1.3	6.1	3.2	S1,Adult,Walk,Light,No	2	16	N	25	1.3	1.1	6.9	3.1	S1,Adult,Walk,Light,No
2	14	N	22	1.4	1.2	5.0	3.1	S1,Adult,Walk,Light,No	2	15	N	25	1.3	1.2	5.5	3.1	S1,Adult,Walk,Light,No
2	11	N	19	1.3	1.0	5.6	3.1	S1,Adult,Walk,Light,No	2	14	N	22	1.5	1.3	5.1	3.1	S1,Adult,Walk,Light,No

OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)	OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)
2	15	N	25	1.5	1.3	5.0	3.2	S1,Adult,Walk,Light,No	2	8	N	13	1.0	0.8	5.2	3.1	S1,Adult,Walk,Light,No
2	12	N	18	1.4	1.2	5.1	3.1	S1,Adult,Walk,Light,No	2	8	N	12	1.1	0.9	5.0	3.2	S1,Adult,Walk,Light,No
2	14	N	22	1.4	1.2	4.9	3.1	S1,Adult,Walk,Light,No	2	6	N	10	0.9	0.7	4.3	3.1	S1,Adult,Walk,Light,No
2	12	N	19	1.3	1.1	5.4	3.1	S1,Adult,Walk,Light,No	2	17	N	28	1.5	1.3	5.3	3.1	S1,Adult,Walk,Light,No
2	10	N	16	1.1	0.9	6.0	3.1	S1,Adult,Walk,Light,No	2	14	N	22	1.4	1.2	5.3	3.1	S1,Adult,Walk,Light,No
2	12	N	19	1.3	1.2	5.3	3.1	S1,Adult,Walk,Light,No	2	19	N	31	1.6	1.4	5.6	3.1	S1,Adult,Walk,Light,No
2	10	N	16	1.2	1.0	5.2	3.1	S1,Adult,Walk,Light,No	2	21	N	34	1.5	1.3	6.2	3.0	S1,Adult,Walk,Light,No
2	10	N	16	1.3	1.1	5.1	3.1	S1,Adult,Walk,Light,No	2	18	N	28	1.5	1.3	5.3	3.1	S1,Adult,Walk,Light,No
2	6	N	10	1.0	0.8	4.7	3.1	S1,Adult,Walk,Light,No	2	21	N	35	1.4	1.2	7.5	3.1	S1,Adult,Walk,Light,No
2	21	N	34	1.5	1.3	7.0	3.1	S1,Adult,Walk,Light,No	2	23	N	38	1.6	1.4	6.9	3.1	S1,Adult,Walk,Light,No
2	14	N	22	1.1	1.0	6.9	3.1	S1,Adult,Walk,Light,No	2	15	N	25	1.3	1.1	6.5	3.1	S1,Adult,Walk,Light,No
2	17	N	28	1.6	1.4	5.1	3.1	S1,Adult,Walk,Light,No	2	16	N	25	1.3	1.2	5.6	3.1	S1,Adult,Walk,Light,No
2	16	N	25	1.5	1.3	5.1	3.1	S1,Adult,Walk,Light,No	2	17	N	28	1.5	1.4	5.2	3.1	S1,Adult,Walk,Light,No
2	16	N	25	1.5	1.3	5.0	3.1	S1,Adult,Walk,Light,No	2	14	N	22	1.3	1.2	5.2	3.1	S1,Adult,Walk,Light,No
2	14	N	22	1.4	1.2	5.2	3.6	S1,Adult,Walk,Light,No	2	14	N	22	1.5	1.3	4.8	3.1	S1,Adult,Walk,Light,No
2	14	N	22	1.5	1.3	4.7	3.2	S1,Adult,Walk,Light,No	2	13	N	21	1.4	1.2	5.2	3.1	S1,Adult,Walk,Light,No
2	12	N	19	1.4	1.2	5.0	3.1	S1,Adult,Walk,Light,No	2	12	N	19	1.3	1.2	5.2	3.1	S1,Adult,Walk,Light,No
2	13	N	22	1.5	1.3	4.7	3.1	S1,Adult,Walk,Light,No	2	10	N	16	1.3	1.1	5.0	3.1	S1,Adult,Walk,Light,No
2	10	N	16	1.2	1.0	5.3	3.2	S1,Adult,Walk,Light,No	2	18	N	28	1.3	1.1	7.0	3.2	S1,Adult,Walk,Light,No
2	8	N	13	1.0	0.8	5.1	3.1	S1,Adult,Walk,Light,No	2	8	N	12	0.7	0.6	6.3	3.1	S1,Adult,Walk,Light,No
2	19	N	31	1.6	1.4	5.4	3.1	S1,Adult,Walk,Light,No	2	10	N	15	0.9	0.8	6.6	3.3	S1,Adult,Walk,Light,No
2	10	N	16	1.0	0.8	5.9	3.1	S1,Adult,Walk,Light,No	2	12	N	19	1.3	1.2	5.1	3.1	S1,Adult,Walk,Light,No
2	12	N	19	1.3	1.1	4.8	3.1	S1,Adult,Walk,Light,No	2	12	N	19	1.3	1.2	5.1	3.1	S1,Adult,Walk,Light,No
2	6	N	9	1.0	0.8	3.8	3.1	S1,Adult,Walk,Light,No	2	6	N	9	0.9	0.8	4.9	3.1	S1,Adult,Walk,Light,No
2	8	N	12	1.1	0.9	4.7	3.2	S1,Adult,Walk,Light,No	2	18	N	28	1.5	1.3	5.3	3.1	S1,Adult,Walk,Light,No
2	17	N	28	1.5	1.4	5.2	3.1	S1,Adult,Walk,Light,No	2	13	N	22	1.3	1.2	4.9	3.1	S1,Adult,Walk,Light,No
2	8	N	13	1.0	0.9	5.8	3.0	S1,Adult,Walk,Light,No	2	21	N	34	1.5	1.4	6.2	3.0	S1,Adult,Walk,Light,No
2	17	N	28	1.5	1.3	5.3	3.1	S1,Adult,Walk,Light,No	2	17	N	28	1.5	1.4	5.3	3.1	S1,Adult,Walk,Light,No
2	21	N	34	1.5	1.4	6.3	3.1	S1,Adult,Walk,Light,No	2	23	N	37	1.4	1.3	7.7	3.2	S1,Adult,Walk,Light,No
2	19	N	31	1.5	1.3	5.8	3.1	S1,Adult,Walk,Light,No	2	19	N	31	1.4	1.2	7.2	3.1	S1,Adult,Walk,Light,No
2	12	N	19	1.2	1.0	6.1	3.1	S1,Adult,Walk,Light,No	2	19	N	31	1.5	1.3	5.7	3.1	S1,Adult,Walk,Light,No
2	19	N	31	1.5	1.3	6.3	3.1	S1,Adult,Walk,Light,No	2	17	N	28	1.5	1.3	5.4	3.1	S1,Adult,Walk,Light,No
2	18	N	28	1.3	1.1	6.6	3.2	S1,Adult,Walk,Light,No	2	12	N	19	1.2	1.1	5.3	3.1	S1,Adult,Walk,Light,No
2	17	N	28	1.4	1.2	5.9	3.1	S1,Adult,Walk,Light,No	2	12	N	19	1.2	1.1	5.5	3.1	S1,Adult,Walk,Light,No
2	16	N	25	1.2	1.1	6.4	3.1	S1,Adult,Walk,Light,No	2	14	N	22	1.4	1.2	5.3	3.1	S1,Adult,Walk,Light,No
2	16	N	25	1.3	1.1	5.6	3.1	S1,Adult,Walk,Light,No	2	10	N	16	1.2	1.0	5.3	3.1	S1,Adult,Walk,Light,No
2	19	N	31	1.6	1.4	5.4	3.1	S1,Adult,Walk,Light,No	2	17	N	28	1.3	1.1	6.7	3.1	S1,Adult,Walk,Light,No
2	13	N	22	1.2	1.0	6.4	3.1	S1,Adult,Walk,Light,No	2	12	N	19	1.0	0.9	6.7	3.1	S1,Adult,Walk,Light,No
2	12	N	19	1.3	1.1	4.9	3.1	S1,Adult,Walk,Light,No	2	13	N	22	1.3	1.1	5.4	3.1	S1,Adult,Walk,Light,No
2	14	N	22	1.3	1.2	5.2	3.1	S1,Adult,Walk,Light,No	2	10	N	15	0.9	0.8	6.1	3.2	S1,Adult,Walk,Light,No
2	14	N	22	1.4	1.3	5.3	3.2	S1,Adult,Walk,Light,No	2	12	N	18	1.3	1.1	4.7	3.1	S1,Adult,Walk,Light,No
2	13	N	21	1.4	1.2	4.8	3.1	S1,Adult,Walk,Light,No	2	8	N	13	1.0	0.9	5.2	3.1	S1,Adult,Walk,Light,No
2	12	N	19	1.4	1.2	5.0	3.1	S1,Adult,Walk,Light,No	2	10	N	16	1.1	1.0	5.4	3.1	S1,Adult,Walk,Light,No
2	8	N	13	1.1	0.9	5.4	3.1	S1,Adult,Walk,Light,No	2	14	N	22	1.4	1.2	5.4	3.1	S1,Adult,Walk,Light,No
2	8	N	13	1.1	1.0	4.9	3.1	S1,Adult,Walk,Light,No	2	23	N	37	1.3	1.1	7.7	3.1	S1,Adult,Walk,Light,No
2	13	N	22	1.1	0.9	6.9	3.1	S1,Adult,Walk,Light,No	2	17	N	28	1.5	1.3	5.2	3.1	S1,Adult,Walk,Light,No
2	17	N	28	1.4	1.2	6.1	3.1	S1,Adult,Walk,Light,No	2	14	N	22	1.4	1.3	4.7	3.1	S1,Adult,Walk,Light,No
2	18	N	28	1.6	1.4	5.9	3.1	S1,Adult,Walk,Light,No	2	16	N	25	1.5	1.3	4.9	3.1	S1,Adult,Walk,Light,No
2	15	N	25	1.5	1.3	4.8	3.1	S1,Adult,Walk,Light,No	2	14	N	22	1.4	1.3	4.8	3.1	S1,Adult,Walk,Light,No
2	10	N	16	1.2	1.0	5.3	3.1	S1,Adult,Walk,Light,No	2	14	N	22	1.4	1.3	5.1	3.2	S1,Adult,Walk,Light,No

OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)	OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)
2	12	N	19	1.4	1.2	4.9	3.1	S1,Adult,Walk,Light,No	2	13	Y	28	1.4	1.2	5.8	3.1	S1,Adult,Walk,Light,No
2	10	N	16	1.3	1.1	4.8	3.2	S1,Adult,Walk,Light,No	2	9	Y	19	1.2	1.1	4.5	3.1	S1,Adult,Walk,Light,No
2	16	N	25	1.5	1.3	4.9	3.1	S1,Adult,Walk,Light,No	2	6	Y	37	0.8	0.6	6.1	3.3	S1,Adult,Walk,Light,No
2	14	N	22	1.3	1.2	5.7	3.1	S1,Adult,Walk,Light,No	2	12	Y	31	1.1	0.9	7.2	3.1	S1,Adult,Walk,Light,No
2	16	N	25	1.5	1.4	4.8	3.1	S1,Adult,Walk,Light,No	2	13	Y	34	1.2	1.1	6.8	3.1	S1,Adult,Walk,Light,No
2	16	N	25	1.5	1.4	4.9	3.1	S1,Adult,Walk,Light,No	2	7	Y	37	0.9	0.7	5.9	3.2	S1,Adult,Walk,Light,No
2	10	N	16	1.2	1.1	5.2	3.1	S1,Adult,Walk,Light,No	2	9	Y	19	0.8	0.7	6.7	3.1	S1,Adult,Walk,Light,No
2	17	N	29	1.4	1.2	6.4	3.1	S1,Adult,Walk,Light,No	2	14	Y	31	1.2	1.1	6.9	3.2	S1,Adult,Walk,Light,No
2	10	N	15	0.9	0.8	6.4	3.1	S1,Adult,Walk,Light,No	2	20	Y	37	1.4	1.3	7.2	3.1	S1,Adult,Walk,Light,No
2	16	N	25	1.5	1.4	4.9	3.1	S1,Adult,Walk,Light,No	2	0	Y	10	0.0	0.0	0.0	3.1	S1,Adult,Walk,Light,No
2	16	N	25	1.4	1.3	5.9	3.1	S1,Adult,Walk,Light,No	2	0	Y	9	0.0	0.0	0.0	3.1	S1,Adult,Walk,Light,No
2	18	N	29	1.6	1.4	5.2	3.2	S1,Adult,Walk,Light,No	3	9	N	9	1.2	0.8	5.1	3.1	S1,Adult,Walk,Light,No
2	6	N	9	0.9	0.8	4.0	3.2	S1,Adult,Walk,Light,No	3	9	N	10	1.2	0.8	5.0	3.1	S1,Adult,Walk,Light,No
2	21	N	34	1.5	1.4	6.5	3.1	S1,Adult,Walk,Light,No	3	13	N	13	1.2	0.8	5.8	3.1	S1,Adult,Walk,Light,No
2	18	N	28	1.4	1.3	6.3	3.0	S1,Adult,Walk,Light,No	3	12	N	12	1.0	0.8	5.4	3.1	S1,Adult,Walk,Light,No
2	12	N	19	1.3	1.2	4.7	3.1	S1,Adult,Walk,Light,No	3	12	N	12	1.1	0.8	5.9	3.1	S1,Adult,Walk,Light,No
2	16	N	25	1.5	1.4	4.9	3.1	S1,Adult,Walk,Light,No	3	15	N	16	1.0	0.8	5.9	3.1	S1,Adult,Walk,Light,No
2	15	N	25	1.5	1.5	4.6	3.1	S1,Adult,Walk,Light,No	3	16	N	16	1.0	0.9	5.8	3.1	S1,Adult,Walk,Light,No
2	21	N	34	1.6	1.7	5.7	3.2	S1,Adult,Walk,Light,No	3	16	N	16	1.0	0.8	6.3	3.1	S1,Adult,Walk,Light,No
2	0	Y	9	0.6	0.0	0.0	3.1	S1,Adult,Walk,Light,No	3	19	N	18	0.7	0.6	7.2	3.1	S1,Adult,Walk,Light,No
2	0	Y	9	0.5	0.0	0.0	3.0	S1,Adult,Walk,Light,No	3	10	N	10	0.8	0.7	6.5	3.1	S1,Adult,Walk,Light,No
2	14	Y	37	1.4	1.0	7.4	3.1	S1,Adult,Walk,Light,No	3	9	N	10	0.8	0.7	6.2	3.1	S1,Adult,Walk,Light,No
2	0	Y	9	0.3	0.0	0.0	3.1	S1,Adult,Walk,Light,No	3	9	N	9	0.7	0.6	6.1	3.1	S1,Adult,Walk,Light,No
2	11	Y	31	1.2	0.9	6.9	3.1	S1,Adult,Walk,Light,No	3	12	N	12	0.8	0.7	5.1	3.1	S1,Adult,Walk,Light,No
2	16	Y	34	1.3	1.1	7.3	3.2	S1,Adult,Walk,Light,No	3	13	N	13	0.9	0.7	5.6	3.1	S1,Adult,Walk,Light,No
2	15	Y	34	1.3	1.0	7.3	3.1	S1,Adult,Walk,Light,No	3	13	N	13	0.8	0.6	7.0	3.1	S1,Adult,Walk,Light,No
2	11	Y	34	1.3	1.1	6.1	3.1	S1,Adult,Walk,Light,No	3	16	N	16	0.8	0.7	7.1	3.2	S1,Adult,Walk,Light,No
2	17	Y	37	1.3	1.1	7.6	3.1	S1,Adult,Walk,Light,No	3	16	N	16	0.7	0.6	7.4	3.1	S1,Adult,Walk,Light,No
2	5	Y	13	0.7	0.5	5.6	3.1	S1,Adult,Walk,Light,No	3	19	N	19	0.8	0.6	7.6	3.1	S1,Adult,Walk,Light,No
2	3	Y	13	0.7	0.5	3.8	3.1	S1,Adult,Walk,Light,No	3	10	N	10	0.5	0.4	6.1	3.1	S1,Adult,Walk,Light,No
2	15	Y	34	1.3	1.1	7.1	3.1	S1,Adult,Walk,Light,No	3	10	N	10	1.1	0.8	5.4	3.1	S1,Adult,Walk,Light,No
2	0	Y	12	0.3	0.1	1.2	3.1	S1,Adult,Walk,Light,No	3	9	N	9	1.1	0.8	5.6	3.1	S1,Adult,Walk,Light,No
2	8	Y	34	1.0	0.8	6.5	3.2	S1,Adult,Walk,Light,No	3	10	N	10	1.2	0.8	5.2	3.1	S1,Adult,Walk,Light,No
2	1	Y	9	0.5	0.3	3.0	3.1	S1,Adult,Walk,Light,No	3	12	N	12	1.1	0.8	6.3	3.1	S1,Adult,Walk,Light,No
2	10	Y	16	1.2	1.0	5.0	3.1	S1,Adult,Walk,Light,No	3	13	N	13	1.0	0.8	6.3	3.1	S1,Adult,Walk,Light,No
2	7	Y	16	1.2	1.0	3.7	3.1	S1,Adult,Walk,Light,No	3	16	N	16	1.0	0.8	6.0	3.1	S1,Adult,Walk,Light,No
2	18	Y	34	1.4	1.2	7.0	3.1	S1,Adult,Walk,Light,No	3	16	N	16	1.0	0.8	6.9	3.1	S1,Adult,Walk,Light,No
2	11	Y	34	1.2	1.0	6.3	3.2	S1,Adult,Walk,Light,No	3	16	N	16	1.0	0.9	5.9	3.1	S1,Adult,Walk,Light,No
2	8	Y	16	0.8	0.6	6.5	3.1	S1,Adult,Walk,Light,No	3	19	N	18	1.0	0.9	7.0	3.1	S1,Adult,Walk,Light,No
2	16	Y	34	1.3	1.1	7.4	3.1	S1,Adult,Walk,Light,No	3	19	N	19	1.0	0.9	7.0	3.1	S1,Adult,Walk,Light,No
2	11	Y	34	1.1	0.9	7.2	3.1	S1,Adult,Walk,Light,No	3	19	N	19	1.0	0.9	6.7	3.3	S1,Adult,Walk,Light,No
2	16	Y	31	1.4	1.2	6.6	3.1	S1,Adult,Walk,Light,No	3	22	N	22	1.0	0.9	7.2	3.1	S1,Adult,Walk,Light,No
2	6	Y	12	0.8	0.6	5.3	3.1	S1,Adult,Walk,Light,No	3	9	N	9	1.1	0.9	3.4	3.1	S1,Adult,Walk,Light,No
2	6	Y	16	1.2	1.0	3.5	3.0	S1,Adult,Walk,Light,No	3	13	N	13	1.1	0.9	5.4	3.1	S1,Adult,Walk,Light,No
2	9	Y	31	1.2	1.1	5.2	3.1	S1,Adult,Walk,Light,No	3	12	N	12	1.2	0.8	5.5	3.1	S1,Adult,Walk,Light,No
2	14	Y	28	1.4	1.3	5.7	3.2	S1,Adult,Walk,Light,No	3	12	N	12	1.2	0.8	5.3	3.1	S1,Adult,Walk,Light,No
2	13	Y	30	1.4	1.2	5.8	3.1	S1,Adult,Walk,Light,No	3	15	N	15	1.1	0.8	6.4	3.1	S1,Adult,Walk,Light,No
2	13	Y	31	1.1	0.9	7.3	3.1	S1,Adult,Walk,Light,No	3	15	N	16	0.8	0.7	5.3	3.1	S1,Adult,Walk,Light,No
2	10	Y	31	1.1	0.9	6.2	3.1	S1,Adult,Walk,Light,No	3	15	N	15	1.0	0.8	6.1	3.1	S1,Adult,Walk,Light,No
2	5	Y	13	0.7	0.5	5.3	3.1	S1,Adult,Walk,Light,No	3	21	N	22	1.1	1.0	5.7	3.1	S1,Adult,Walk,Light,No

OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)	OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)
3	21	N	21	1.1	1.0	6.8	3.2	S1,Adult,Walk,Light,No	3	1	Y	10	0.5	0.4	1.2	3.1	S1,Adult,Walk,Light,No
3	24	N	24	1.0	0.9	7.0	3.1	S1,Adult,Walk,Light,No	3	6	Y	12	0.5	0.4	5.2	3.1	S1,Adult,Walk,Light,No
3	24	N	25	1.2	1.1	5.0	3.1	S1,Adult,Walk,Light,No	3	4	Y	12	0.5	0.5	2.5	3.1	S1,Adult,Walk,Light,No
3	10	N	10	0.6	0.5	6.2	3.1	S1,Adult,Walk,Light,No	3	0	Y	12	0.0	0.0	0.0	3.1	S1,Adult,Walk,Light,No
3	10	N	10	0.7	0.6	6.3	3.2	S1,Adult,Walk,Light,No	3	0	Y	15	0.5	0.0	0.0	3.1	S1,Adult,Walk,Light,No
3	9	N	9	0.9	0.7	4.6	3.1	S1,Adult,Walk,Light,No	3	0	Y	16	0.6	0.0	0.0	3.1	S1,Adult,Walk,Light,No
3	10	N	10	1.1	0.8	5.0	3.1	S1,Adult,Walk,Light,No	3	2	Y	27	1.0	0.8	0.7	3.1	S1,Adult,Walk,Light,No
3	9	N	9	1.2	0.8	4.8	3.1	S1,Adult,Walk,Light,No	3	0	Y	9	0.0	0.0	0.0	3.1	S1,Adult,Walk,Light,No
3	12	N	12	1.2	0.9	5.3	3.1	S1,Adult,Walk,Light,No	3	0	Y	9	0.0	0.0	0.0	3.1	S1,Adult,Walk,Light,No
3	12	N	12	1.1	0.9	4.6	3.1	S1,Adult,Walk,Light,No	3	0	Y	13	0.2	0.0	0.0	3.1	S1,Adult,Walk,Light,No
3	13	N	13	1.1	0.9	4.4	3.1	S1,Adult,Walk,Light,No	3	0	Y	13	0.0	0.0	0.0	3.1	S1,Adult,Walk,Light,No
3	15	N	15	1.0	0.9	5.6	3.5	S1,Adult,Walk,Light,No	3	0	Y	13	0.0	0.0	0.0	3.1	S1,Adult,Walk,Light,No
3	16	N	16	1.3	1.1	5.2	3.1	S1,Adult,Walk,Light,No	1	12	N	12	1.4	0.6	6.5	3.1	S1,Child,Walk,Light,No
3	15	N	15	1.2	1.0	5.3	3.1	S1,Adult,Walk,Light,No	1	15	N	15	1.6	0.8	7.1	3.2	S1,Child,Walk,Light,No
3	18	N	18	1.2	1.1	5.5	3.2	S1,Adult,Walk,Light,No	1	16	N	16	1.5	0.7	6.8	3.1	S1,Child,Walk,Light,No
3	18	N	18	1.4	1.1	4.2	3.1	S1,Adult,Walk,Light,No	1	16	N	15	1.6	0.7	6.8	3.1	S1,Child,Walk,Light,No
3	18	N	18	1.2	1.1	4.2	3.1	S1,Adult,Walk,Light,No	1	12	N	12	1.5	0.7	7.0	3.1	S1,Child,Walk,Light,No
3	22	N	22	1.1	1.1	6.2	3.2	S1,Adult,Walk,Light,No	1	12	N	12	1.5	0.7	7.0	3.1	S1,Child,Walk,Light,No
3	21	N	21	1.0	1.0	6.2	3.1	S1,Adult,Walk,Light,No	1	13	N	12	1.5	0.7	7.2	3.1	S1,Child,Walk,Light,No
3	21	N	21	1.1	1.0	6.8	3.1	S1,Adult,Walk,Light,No	1	15	N	15	1.5	0.8	7.0	3.1	S1,Child,Walk,Light,No
3	25	N	25	1.1	1.0	6.8	3.1	S1,Adult,Walk,Light,No	1	13	N	13	1.5	0.7	6.8	3.1	S1,Child,Walk,Light,No
3	25	N	25	1.1	1.0	6.6	3.1	S1,Adult,Walk,Light,No	1	13	N	13	1.4	0.7	6.8	3.1	S1,Child,Walk,Light,No
3	24	N	24	1.0	1.0	6.1	3.5	S1,Adult,Walk,Light,No	1	16	N	16	1.4	0.7	6.8	3.1	S1,Child,Walk,Light,No
3	28	N	28	1.1	1.0	6.5	3.2	S1,Adult,Walk,Light,No	1	19	N	19	1.6	0.9	7.3	3.1	S1,Child,Walk,Light,No
3	0	Y	19	0.0	0.0	0.0	3.1	S1,Adult,Walk,Light,No	1	10	N	10	1.3	0.6	6.5	3.1	S1,Child,Walk,Light,No
3	0	Y	19	0.0	0.0	0.0	3.1	S1,Adult,Walk,Light,No	1	9	N	10	1.3	0.6	6.8	3.1	S1,Child,Walk,Light,No
3	0	Y	22	0.0	0.0	0.0	3.1	S1,Adult,Walk,Light,No	1	19	N	19	1.5	0.9	7.4	3.2	S1,Child,Walk,Light,No
3	6	Y	22	0.6	0.4	6.1	3.1	S1,Adult,Walk,Light,No	1	15	N	15	1.5	0.8	6.8	3.1	S1,Child,Walk,Light,No
3	0	Y	22	0.0	0.0	0.0	3.1	S1,Adult,Walk,Light,No	1	10	N	10	1.3	0.6	6.4	3.1	S1,Child,Walk,Light,No
3	9	Y	16	0.7	0.6	5.4	3.0	S1,Adult,Walk,Light,No	1	13	N	13	1.4	0.7	6.6	3.1	S1,Child,Walk,Light,No
3	13	Y	19	0.7	0.5	7.3	3.1	S1,Adult,Walk,Light,No	1	10	N	10	1.2	0.6	6.4	3.1	S1,Child,Walk,Light,No
3	14	Y	19	0.7	0.6	7.1	3.1	S1,Adult,Walk,Light,No	1	10	N	10	1.2	0.6	6.9	3.1	S1,Child,Walk,Light,No
3	11	Y	22	0.7	0.6	7.1	3.2	S1,Adult,Walk,Light,No	1	21	N	22	1.6	1.0	7.3	3.1	S1,Child,Walk,Light,No
3	10	Y	22	0.7	0.5	7.0	3.1	S1,Adult,Walk,Light,No	1	22	N	22	1.7	1.1	7.0	3.1	S1,Child,Walk,Light,No
3	0	Y	22	0.6	0.3	0.8	3.1	S1,Adult,Walk,Light,No	1	9	N	9	1.2	0.6	6.3	3.0	S1,Child,Walk,Light,No
3	3	Y	10	0.6	0.5	2.1	3.1	S1,Adult,Walk,Light,No	1	22	N	22	1.6	1.0	7.1	3.1	S1,Child,Walk,Light,No
3	3	Y	10	0.5	0.4	3.2	3.1	S1,Adult,Walk,Light,No	1	19	N	19	1.5	0.9	6.9	3.1	S1,Child,Walk,Light,No
3	0	Y	12	0.4	0.2	0.7	3.1	S1,Adult,Walk,Light,No	1	9	N	9	1.2	0.6	6.2	3.1	S1,Child,Walk,Light,No
3	1	Y	13	0.5	0.3	1.3	3.1	S1,Adult,Walk,Light,No	1	16	N	16	1.5	0.9	6.4	3.2	S1,Child,Walk,Light,No
3	3	Y	13	1.1	0.4	2.4	3.1	S1,Adult,Walk,Light,No	1	19	N	19	1.5	0.9	7.0	3.1	S1,Child,Walk,Light,No
3	11	Y	22	1.0	0.9	4.3	3.0	S1,Adult,Walk,Light,No	1	19	N	19	1.5	1.0	6.9	3.1	S1,Child,Walk,Light,No
3	0	Y	22	1.0	0.0	0.0	3.1	S1,Adult,Walk,Light,No	1	10	N	10	1.2	0.7	6.1	3.1	S1,Child,Walk,Light,No
3	0	Y	10	0.2	0.0	0.0	3.1	S1,Adult,Walk,Light,No	1	9	N	9	1.2	0.7	6.4	3.1	S1,Child,Walk,Light,No
3	0	Y	10	0.0	0.0	0.0	3.1	S1,Adult,Walk,Light,No	1	13	N	12	1.2	0.7	6.5	3.1	S1,Child,Walk,Light,No
3	5	Y	18	0.5	0.5	3.0	3.1	S1,Adult,Walk,Light,No	1	19	N	19	1.5	1.0	6.6	3.1	S1,Child,Walk,Light,No
3	5	Y	18	1.2	1.0	1.6	3.1	S1,Adult,Walk,Light,No	1	22	N	22	1.5	1.0	7.0	3.1	S1,Child,Walk,Light,No
3	5	Y	18	0.6	0.5	3.5	3.1	S1,Adult,Walk,Light,No	1	22	N	22	1.6	1.1	7.1	3.1	S1,Child,Walk,Light,No
3	9	Y	21	1.2	1.1	2.6	3.1	S1,Adult,Walk,Light,No	1	13	N	13	1.2	0.7	6.8	3.1	S1,Child,Walk,Light,No
3	2	Y	24	0.9	1.1	0.6	3.1	S1,Adult,Walk,Light,No	1	16	N	16	1.3	0.8	6.7	3.1	S1,Child,Walk,Light,No
3	2	Y	28	1.0	0.8	0.7	3.1	S1,Adult,Walk,Light,No	1	16	N	16	1.3	0.8	6.7	3.1	S1,Child,Walk,Light,No

OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)	OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)
1	28	N	28	1.6	1.1	8.1	3.1	S1,Child,Walk,Light,No	2	6	N	9	0.9	0.7	4.6	3.1	S1,Child,Walk,Light,No
1	19	N	19	1.2	0.8	7.6	3.1	S1,Child,Walk,Light,No	2	19	N	31	1.6	1.4	6.1	3.1	S1,Child,Walk,Light,No
1	25	N	25	1.5	1.1	7.2	3.1	S1,Child,Walk,Light,No	2	19	N	31	1.5	1.3	5.4	3.1	S1,Child,Walk,Light,No
1	28	N	28	1.5	1.1	7.9	3.1	S1,Child,Walk,Light,No	2	15	N	25	1.4	1.2	5.1	3.1	S1,Child,Walk,Light,No
1	25	N	25	1.6	1.2	7.1	3.1	S1,Child,Walk,Light,No	2	8	N	13	0.9	0.7	5.6	3.1	S1,Child,Walk,Light,No
1	28	N	28	1.5	1.1	8.2	3.1	S1,Child,Walk,Light,No	2	10	N	16	1.1	0.9	5.8	3.1	S1,Child,Walk,Light,No
1	25	N	25	1.4	1.0	7.9	3.1	S1,Child,Walk,Light,No	2	8	N	13	0.9	0.7	5.8	3.1	S1,Child,Walk,Light,No
1	22	N	22	1.4	1.0	7.4	3.1	S1,Child,Walk,Light,No	2	19	N	31	1.5	1.3	6.2	3.1	S1,Child,Walk,Light,No
1	19	N	18	1.3	0.9	7.0	3.1	S1,Child,Walk,Light,No	2	8	N	12	1.0	0.8	5.3	3.1	S1,Child,Walk,Light,No
1	25	N	25	1.5	1.2	7.3	3.1	S1,Child,Walk,Light,No	2	8	N	13	1.1	0.9	5.2	3.2	S1,Child,Walk,Light,No
1	25	N	25	1.5	1.2	7.3	3.1	S1,Child,Walk,Light,No	2	6	N	10	1.0	0.8	4.3	3.0	S1,Child,Walk,Light,No
1	25	N	25	1.5	1.1	7.9	3.1	S1,Child,Walk,Light,No	2	6	N	9	1.0	0.8	4.0	3.1	S1,Child,Walk,Light,No
1	34	N	34	1.4	1.1	8.2	3.1	S1,Child,Walk,Light,No	2	6	N	9	1.0	0.8	4.1	3.2	S1,Child,Walk,Light,No
1	31	N	31	1.4	1.1	8.4	3.1	S1,Child,Walk,Light,No	2	19	N	31	1.5	1.3	6.1	3.2	S1,Child,Walk,Light,No
1	23	N	23	1.4	1.1	7.3	3.1	S1,Child,Walk,Light,No	2	21	N	34	1.5	1.3	6.8	3.0	S1,Child,Walk,Light,No
1	28	N	28	1.4	1.2	8.0	3.1	S1,Child,Walk,Light,No	2	12	N	19	1.0	0.8	7.2	3.1	S1,Child,Walk,Light,No
1	25	N	25	1.4	1.1	7.4	3.2	S1,Child,Walk,Light,No	2	15	N	25	1.5	1.3	5.1	3.1	S1,Child,Walk,Light,No
1	34	N	34	1.4	1.1	8.4	3.1	S1,Child,Walk,Light,No	2	17	N	28	1.4	1.3	5.5	3.1	S1,Child,Walk,Light,No
1	28	N	28	1.4	1.1	8.2	3.1	S1,Child,Walk,Light,No	2	17	N	28	1.5	1.3	5.2	3.1	S1,Child,Walk,Light,No
1	25	N	25	1.4	1.2	7.5	3.1	S1,Child,Walk,Light,No	2	14	N	22	1.4	1.2	5.5	3.1	S1,Child,Walk,Light,No
1	31	N	32	1.3	1.0	8.5	3.1	S1,Child,Walk,Light,No	2	12	N	19	1.4	1.2	4.2	3.1	S1,Child,Walk,Light,No
1	25	N	25	1.3	1.1	7.7	3.1	S1,Child,Walk,Light,No	2	8	N	13	1.1	0.9	4.7	3.1	S1,Child,Walk,Light,No
1	28	N	28	1.3	1.1	8.0	3.2	S1,Child,Walk,Light,No	2	18	N	29	1.4	1.2	5.8	3.2	S1,Child,Walk,Light,No
1	22	N	22	1.2	1.0	7.1	3.0	S1,Child,Walk,Light,No	2	10	N	16	1.1	0.9	6.0	3.1	S1,Child,Walk,Light,No
1	34	N	34	1.2	1.0	8.7	3.1	S1,Child,Walk,Light,No	2	6	N	9	0.9	0.7	4.6	3.1	S1,Child,Walk,Light,No
1	31	N	31	1.2	1.0	6.5	3.1	S1,Child,Walk,Light,No	2	16	N	25	1.5	1.3	4.9	3.1	S1,Child,Walk,Light,No
1	34	N	34	1.3	1.1	8.5	3.1	S1,Child,Walk,Light,No	2	10	N	16	1.2	1.1	4.9	3.1	S1,Child,Walk,Light,No
1	31	N	31	1.3	1.1	8.4	3.1	S1,Child,Walk,Light,No	2	8	N	13	1.1	1.0	4.3	3.1	S1,Child,Walk,Light,No
1	28	N	28	1.3	1.1	7.8	3.1	S1,Child,Walk,Light,No	2	18	N	28	1.5	1.3	5.5	3.1	S1,Child,Walk,Light,No
1	31	N	31	1.3	1.2	8.5	3.1	S1,Child,Walk,Light,No	2	21	N	34	1.3	1.1	7.4	3.1	S1,Child,Walk,Light,No
1	31	N	32	1.2	1.1	8.4	3.1	S1,Child,Walk,Light,No	2	21	N	34	1.3	1.1	7.3	3.1	S1,Child,Walk,Light,No
1	29	N	28	1.3	1.1	6.0	3.1	S1,Child,Walk,Light,No	2	21	N	34	1.5	1.4	6.1	3.1	S1,Child,Walk,Light,No
1	19	N	19	1.0	0.9	6.9	3.1	S1,Child,Walk,Light,No	2	17	N	28	1.3	1.1	7.2	3.1	S1,Child,Walk,Light,No
1	34	N	34	1.1	1.0	8.4	3.1	S1,Child,Walk,Light,No	2	19	N	31	1.4	1.2	6.6	3.1	S1,Child,Walk,Light,No
1	31	N	31	1.2	1.1	8.5	3.1	S1,Child,Walk,Light,No	2	19	N	31	1.5	1.3	5.8	3.1	S1,Child,Walk,Light,No
1	31	N	31	1.2	1.1	6.8	3.1	S1,Child,Walk,Light,No	2	14	N	22	1.5	1.3	5.2	3.1	S1,Child,Walk,Light,No
1	19	Y	37	1.5	0.9	7.8	3.1	S1,Child,Walk,Light,No	2	8	N	12	1.0	0.8	3.6	3.1	S1,Child,Walk,Light,No
1	20	Y	37	1.4	0.8	7.8	3.1	S1,Child,Walk,Light,No	2	16	N	25	1.4	1.3	5.1	3.1	S1,Child,Walk,Light,No
1	12	Y	22	0.7	0.6	7.4	3.1	S1,Child,Walk,Light,No	2	14	N	22	1.3	1.1	5.7	3.1	S1,Child,Walk,Light,No
1	27	Y	34	1.1	0.9	8.3	3.1	S1,Child,Walk,Light,No	2	13	N	21	1.4	1.3	5.2	3.1	S1,Child,Walk,Light,No
1	13	Y	31	0.8	0.7	7.2	3.1	S1,Child,Walk,Light,No	2	10	N	15	1.2	1.0	5.0	3.1	S1,Child,Walk,Light,No
1	15	Y	34	0.8	0.7	7.7	3.1	S1,Child,Walk,Light,No	2	12	N	19	1.3	1.2	5.2	3.1	S1,Child,Walk,Light,No
1	26	Y	34	1.0	0.9	8.2	3.1	S1,Child,Walk,Light,No	2	16	N	25	1.5	1.3	5.0	3.1	S1,Child,Walk,Light,No
1	17	Y	34	0.9	0.8	7.4	3.1	S1,Child,Walk,Light,No	2	14	N	22	1.3	1.1	5.3	3.1	S1,Child,Walk,Light,No
1	13	Y	28	0.7	0.7	7.2	3.1	S1,Child,Walk,Light,No	2	15	N	25	1.2	1.0	6.8	3.1	S1,Child,Walk,Light,No
2	10	N	16	1.1	0.8	6.6	3.1	S1,Child,Walk,Light,No	2	14	N	22	1.4	1.2	4.9	3.1	S1,Child,Walk,Light,No
2	16	N	26	1.5	1.3	5.1	3.1	S1,Child,Walk,Light,No	2	14	N	22	1.5	1.3	5.1	3.3	S1,Child,Walk,Light,No
2	12	N	19	1.3	1.1	5.7	3.1	S1,Child,Walk,Light,No	2	16	N	25	1.5	1.3	5.0	3.1	S1,Child,Walk,Light,No
2	10	N	15	1.2	1.0	5.4	3.1	S1,Child,Walk,Light,No	2	12	N	19	1.4	1.2	3.5	3.1	S1,Child,Walk,Light,No
2	8	N	12	1.0	0.8	5.5	3.1	S1,Child,Walk,Light,No	2	10	N	16	1.2	1.1	5.0	3.1	S1,Child,Walk,Light,No

OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)	OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)
2	11	N	18	1.3	1.1	5.2	3.1	S1,Child,Walk,Light,No	3	0	Y	19	0.0	0.0	0.0	3.1	S1,Child,Walk,Light,No
2	20	N	32	1.3	1.1	7.3	3.1	S1,Child,Walk,Light,No	3	0	Y	19	0.7	0.0	0.0	3.1	S1,Child,Walk,Light,No
2	12	N	19	1.4	1.2	4.9	3.1	S1,Child,Walk,Light,No	3	0	Y	19	0.6	0.0	0.0	3.1	S1,Child,Walk,Light,No
2	18	N	28	1.2	1.0	7.0	3.1	S1,Child,Walk,Light,No	3	0	Y	13	0.0	0.0	0.0	3.1	S1,Child,Walk,Light,No
2	20	N	31	1.4	1.2	6.9	3.1	S1,Child,Walk,Light,No	3	11	Y	16	0.6	0.5	6.4	3.1	S1,Child,Walk,Light,No
2	14	N	22	1.3	1.2	5.0	3.1	S1,Child,Walk,Light,No	3	0	Y	16	0.5	0.0	0.0	3.1	S1,Child,Walk,Light,No
2	12	N	19	1.3	1.2	5.1	3.1	S1,Child,Walk,Light,No	1	9	N	10	0.9	0.6	7.1	3.1	S1,Child,Walk,Light,Yes
2	13	N	22	1.4	1.3	4.9	3.1	S1,Child,Walk,Light,No	1	10	N	10	0.8	0.6	6.1	3.1	S1,Child,Walk,Light,Yes
2	12	N	19	1.3	1.1	5.2	3.1	S1,Child,Walk,Light,No	1	9	N	9	0.8	0.5	7.1	3.2	S1,Child,Walk,Light,Yes
2	17	N	28	1.3	1.2	5.3	3.2	S1,Child,Walk,Light,No	1	10	N	10	0.8	0.6	6.2	3.5	S1,Child,Walk,Light,Yes
2	8	N	12	0.9	0.7	5.7	3.1	S1,Child,Walk,Light,No	1	13	N	12	0.6	0.5	7.1	3.3	S1,Child,Walk,Light,Yes
2	10	N	16	1.3	1.1	4.4	3.1	S1,Child,Walk,Light,No	1	13	N	13	0.6	0.5	7.0	3.1	S1,Child,Walk,Light,Yes
2	16	N	25	1.5	1.4	4.7	3.1	S1,Child,Walk,Light,No	1	10	N	10	0.6	0.5	6.2	3.1	S1,Child,Walk,Light,Yes
2	17	N	28	1.4	1.3	5.5	3.1	S1,Child,Walk,Light,No	1	16	N	16	0.7	0.6	7.1	3.1	S1,Child,Walk,Light,Yes
2	6	N	10	0.9	0.8	3.9	3.1	S1,Child,Walk,Light,No	1	13	N	12	0.6	0.5	7.1	3.2	S1,Child,Walk,Light,Yes
2	20	N	31	1.6	1.5	5.3	3.2	S1,Child,Walk,Light,No	1	10	N	10	0.6	0.5	6.2	3.1	S1,Child,Walk,Light,Yes
2	14	Y	37	1.2	1.0	7.7	3.1	S1,Child,Walk,Light,No	1	10	N	10	0.8	0.7	6.6	3.1	S1,Child,Walk,Light,Yes
2	2	Y	10	0.9	0.7	1.9	3.1	S1,Child,Walk,Light,No	1	9	N	9	0.6	0.5	6.6	3.1	S1,Child,Walk,Light,Yes
2	14	Y	28	1.2	1.0	6.9	3.2	S1,Child,Walk,Light,No	1	15	N	15	0.6	0.6	7.2	3.4	S1,Child,Walk,Light,Yes
2	8	Y	15	0.8	0.6	6.8	3.1	S1,Child,Walk,Light,No	1	16	N	16	0.7	0.6	7.3	3.1	S1,Child,Walk,Light,Yes
2	11	Y	37	1.1	0.9	7.3	3.1	S1,Child,Walk,Light,No	1	1	Y	10	0.5	0.2	3.2	3.1	S1,Child,Walk,Light,Yes
2	2	Y	10	0.8	0.6	2.2	3.1	S1,Child,Walk,Light,No	1	4	Y	16	0.4	0.3	5.1	3.1	S1,Child,Walk,Light,Yes
2	1	Y	10	0.8	0.6	1.3	3.1	S1,Child,Walk,Light,No	1	8	Y	12	0.5	0.4	6.2	3.1	S1,Child,Walk,Light,Yes
2	12	Y	35	1.1	1.0	7.0	3.1	S1,Child,Walk,Light,No	1	9	Y	19	0.6	0.5	6.1	3.1	S1,Child,Walk,Light,Yes
2	8	Y	37	1.0	0.9	5.4	3.1	S1,Child,Walk,Light,No	1	4	Y	16	0.4	0.3	5.3	3.1	S1,Child,Walk,Light,Yes
3	9	N	9	1.0	0.7	5.7	3.1	S1,Child,Walk,Light,No	1	5	Y	22	0.4	0.3	6.0	3.1	S1,Child,Walk,Light,Yes
3	10	N	10	1.0	0.7	5.4	3.1	S1,Child,Walk,Light,No	1	10	Y	13	0.6	0.5	6.3	3.1	S1,Child,Walk,Light,Yes
3	9	N	10	0.8	0.6	6.0	3.1	S1,Child,Walk,Light,No	1	3	Y	13	0.3	0.2	4.9	3.1	S1,Child,Walk,Light,Yes
3	13	N	13	0.7	0.6	6.2	3.1	S1,Child,Walk,Light,No	1	7	Y	19	0.5	0.4	6.0	3.1	S1,Child,Walk,Light,Yes
3	12	N	12	0.7	0.6	6.7	3.1	S1,Child,Walk,Light,No	1	8	Y	19	0.6	0.5	6.0	3.1	S1,Child,Walk,Light,Yes
3	12	N	12	0.7	0.6	5.1	3.1	S1,Child,Walk,Light,No	1	12	Y	19	0.7	0.6	7.0	3.2	S1,Child,Walk,Light,Yes
3	9	N	10	0.9	0.7	6.3	0.0	S1,Child,Walk,Light,No	1	8	Y	13	0.5	0.4	6.1	3.1	S1,Child,Walk,Light,Yes
3	9	N	10	0.9	0.8	5.6	3.1	S1,Child,Walk,Light,No	1	5	Y	16	0.5	0.4	5.3	3.1	S1,Child,Walk,Light,Yes
3	9	N	9	0.9	0.8	5.9	3.1	S1,Child,Walk,Light,No	1	10	Y	16	0.6	0.5	6.7	3.1	S1,Child,Walk,Light,Yes
3	13	N	13	0.8	0.6	6.7	3.1	S1,Child,Walk,Light,No	1	6	Y	16	0.5	0.4	5.9	3.1	S1,Child,Walk,Light,Yes
3	13	N	13	0.8	0.6	5.9	3.1	S1,Child,Walk,Light,No	1	10	Y	19	0.6	0.5	6.4	3.1	S1,Child,Walk,Light,Yes
3	13	N	12	0.8	0.7	6.9	3.1	S1,Child,Walk,Light,No	1	2	Y	12	0.2	0.2	4.1	3.1	S1,Child,Walk,Light,Yes
3	16	N	16	0.8	0.7	7.1	3.1	S1,Child,Walk,Light,No	1	2	Y	22	0.3	0.2	3.3	3.1	S1,Child,Walk,Light,Yes
3	16	N	16	0.7	0.6	7.5	3.1	S1,Child,Walk,Light,No	1	11	Y	16	0.6	0.5	6.6	3.1	S1,Child,Walk,Light,Yes
3	16	N	16	0.8	0.7	6.5	3.1	S1,Child,Walk,Light,No	1	14	Y	18	0.7	0.6	7.3	3.1	S1,Child,Walk,Light,Yes
3	19	N	19	0.7	0.6	7.6	3.1	S1,Child,Walk,Light,No	1	2	Y	12	0.3	0.2	3.8	3.1	S1,Child,Walk,Light,Yes
3	10	N	10	0.8	0.7	6.1	3.1	S1,Child,Walk,Light,No	1	2	Y	18	0.3	0.2	4.1	3.3	S1,Child,Walk,Light,Yes
3	10	N	10	0.8	0.7	6.2	3.1	S1,Child,Walk,Light,No	1	0	Y	22	0.0	0.0	0.0	3.1	S1,Child,Walk,Light,Yes
3	10	N	10	0.8	0.7	5.9	3.1	S1,Child,Walk,Light,No	2	6	N	9	0.9	0.7	3.1	3.2	S1,Child,Walk,Light,Yes
3	13	N	13	0.8	0.7	6.4	3.1	S1,Child,Walk,Light,No	2	10	N	16	0.8	0.6	7.2	3.1	S1,Child,Walk,Light,Yes
3	13	N	13	0.7	0.6	6.6	3.1	S1,Child,Walk,Light,No	2	6	N	10	0.8	0.5	5.3	3.5	S1,Child,Walk,Light,Yes
3	16	N	16	0.8	0.7	7.0	3.1	S1,Child,Walk,Light,No	2	6	N	9	0.8	0.6	4.3	3.1	S1,Child,Walk,Light,Yes
3	11	Y	15	0.6	0.5	6.7	3.1	S1,Child,Walk,Light,No	2	6	N	10	0.8	0.6	5.5	3.1	S1,Child,Walk,Light,Yes
3	9	Y	16	0.6	0.5	6.3	3.1	S1,Child,Walk,Light,No	2	8	N	13	0.9	0.7	6.5	3.1	S1,Child,Walk,Light,Yes
3	8	Y	16	0.6	0.5	6.0	3.1	S1,Child,Walk,Light,No	2	8	N	13	0.8	0.6	6.7	3.1	S1,Child,Walk,Light,Yes

OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)	OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)
2	6	N	10	0.8	0.6	4.9	3.1	S1,Child,Walk,Light,Yes	3	9	Y	15	0.6	0.5	6.0	3.1	S1,Child,Walk,Light,Yes
2	6	N	10	0.7	0.5	5.7	3.1	S1,Child,Walk,Light,Yes	3	7	Y	16	0.6	0.5	5.1	3.1	S1,Child,Walk,Light,Yes
2	6	N	10	0.9	0.7	5.0	3.1	S1,Child,Walk,Light,Yes	3	0	Y	19	0.2	0.0	0.0	3.1	S1,Child,Walk,Light,Yes
2	6	N	9	0.7	0.6	4.2	3.2	S1,Child,Walk,Light,Yes	3	0	Y	10	0.6	0.0	0.0	3.1	S1,Child,Walk,Light,Yes
2	10	N	16	0.7	0.6	6.8	3.4	S1,Child,Walk,Light,Yes	3	2	Y	10	0.4	0.3	2.5	3.1	S1,Child,Walk,Light,Yes
2	8	N	13	0.8	0.7	6.4	3.2	S1,Child,Walk,Light,Yes	3	0	Y	13	0.2	0.0	0.0	3.1	S1,Child,Walk,Light,Yes
2	0	Y	13	0.4	0.0	0.0	3.2	S1,Child,Walk,Light,Yes	3	1	Y	13	0.7	0.2	2.2	3.1	S1,Child,Walk,Light,Yes
2	2	Y	9	0.6	0.4	4.0	3.1	S1,Child,Walk,Light,Yes	3	13	Y	22	0.7	0.6	7.2	3.1	S1,Child,Walk,Light,Yes
2	3	Y	22	0.6	0.4	4.7	3.1	S1,Child,Walk,Light,Yes	3	11	Y	22	0.7	0.6	6.8	3.1	S1,Child,Walk,Light,Yes
2	6	Y	12	0.7	0.5	6.0	3.2	S1,Child,Walk,Light,Yes	3	12	Y	23	0.7	0.6	7.1	3.1	S1,Child,Walk,Light,Yes
2	4	Y	15	0.6	0.4	4.9	3.1	S1,Child,Walk,Light,Yes	3	10	Y	25	0.7	0.6	6.8	3.1	S1,Child,Walk,Light,Yes
2	5	Y	16	0.6	0.5	5.5	3.1	S1,Child,Walk,Light,Yes	3	10	Y	25	0.7	0.7	6.1	3.1	S1,Child,Walk,Light,Yes
2	2	Y	12	0.5	0.4	4.1	3.1	S1,Child,Walk,Light,Yes	3	10	Y	25	0.7	0.5	6.9	3.1	S1,Child,Walk,Light,Yes
2	3	Y	12	0.6	0.4	4.7	3.1	S1,Child,Walk,Light,Yes	3	10	Y	28	0.7	0.6	6.9	3.2	S1,Child,Walk,Light,Yes
2	2	Y	19	0.5	0.4	3.9	3.1	S1,Child,Walk,Light,Yes	1	9	N	10	1.2	0.5	6.4	0.0	S4,Adult,Stat,Light,No
2	7	Y	19	0.7	0.6	6.2	3.1	S1,Child,Walk,Light,Yes	1	9	N	9	1.3	0.6	6.2	0.0	S4,Adult,Stat,Light,No
2	1	Y	12	0.3	0.2	1.8	3.2	S1,Child,Walk,Light,Yes	1	9	N	10	1.5	0.7	6.5	0.0	S4,Adult,Stat,Light,No
2	5	Y	19	0.7	0.5	6.2	3.1	S1,Child,Walk,Light,Yes	1	12	N	12	1.3	0.6	6.9	0.0	S4,Adult,Stat,Light,No
2	2	Y	12	0.5	0.3	3.8	3.1	S1,Child,Walk,Light,Yes	1	12	N	13	1.3	0.7	6.9	0.0	S4,Adult,Stat,Light,No
2	5	Y	28	0.7	0.6	5.3	3.1	S1,Child,Walk,Light,Yes	1	13	N	13	1.0	0.7	6.8	0.0	S4,Adult,Stat,Light,No
2	3	Y	19	0.6	0.4	4.7	3.1	S1,Child,Walk,Light,Yes	1	16	N	16	1.4	0.9	6.8	0.0	S4,Adult,Stat,Light,No
2	4	Y	25	0.6	0.5	5.3	3.1	S1,Child,Walk,Light,Yes	1	16	N	15	1.4	0.9	7.0	0.0	S4,Adult,Stat,Light,No
2	6	Y	22	0.7	0.6	5.9	3.1	S1,Child,Walk,Light,Yes	1	19	N	19	1.6	0.9	7.2	0.0	S4,Adult,Stat,Light,No
2	4	Y	25	0.6	0.5	5.1	3.0	S1,Child,Walk,Light,Yes	1	19	N	19	0.6	0.7	7.5	0.0	S4,Adult,Stat,Light,No
2	4	Y	25	0.6	0.5	4.5	3.1	S1,Child,Walk,Light,Yes	1	18	N	19	1.6	0.9	7.4	0.0	S4,Adult,Stat,Light,No
2	7	Y	16	0.6	0.5	6.6	3.1	S1,Child,Walk,Light,Yes	1	22	N	22	1.4	0.9	7.6	0.0	S4,Adult,Stat,Light,No
2	3	Y	22	0.6	0.4	3.1	3.1	S1,Child,Walk,Light,Yes	1	22	N	22	1.6	1.1	7.0	0.0	S4,Adult,Stat,Light,No
2	6	Y	22	0.7	0.6	6.2	3.1	S1,Child,Walk,Light,Yes	1	22	N	22	1.6	0.9	7.5	0.0	S4,Adult,Stat,Light,No
2	3	Y	20	0.5	0.4	3.6	3.1	S1,Child,Walk,Light,Yes	1	25	N	25	1.5	1.1	7.4	0.0	S4,Adult,Stat,Light,No
2	5	Y	16	0.7	0.6	5.1	3.0	S1,Child,Walk,Light,Yes	1	25	N	25	1.6	1.0	7.8	0.0	S4,Adult,Stat,Light,No
2	5	Y	19	0.6	0.5	6.1	3.1	S1,Child,Walk,Light,Yes	1	28	N	29	1.7	1.0	7.5	0.0	S4,Adult,Stat,Light,No
3	9	N	10	0.7	0.6	6.3	3.2	S1,Child,Walk,Light,Yes	1	28	N	28	1.7	1.2	8.0	0.0	S4,Adult,Stat,Light,No
3	10	N	9	0.5	0.4	6.5	3.1	S1,Child,Walk,Light,Yes	1	28	N	28	1.5	1.1	7.9	0.0	S4,Adult,Stat,Light,No
3	16	N	16	0.8	0.7	5.9	3.5	S1,Child,Walk,Light,Yes	1	31	N	31	1.6	1.1	7.2	0.0	S4,Adult,Stat,Light,No
3	9	N	9	1.0	0.8	5.2	3.1	S1,Child,Walk,Light,Yes	1	31	N	31	1.2	1.1	7.3	0.0	S4,Adult,Stat,Light,No
3	9	N	10	1.0	0.8	5.3	3.1	S1,Child,Walk,Light,Yes	1	31	N	31	1.7	1.1	8.0	0.0	S4,Adult,Stat,Light,No
3	9	N	10	0.9	0.8	5.5	3.0	S1,Child,Walk,Light,Yes	1	34	N	35	1.8	1.1	7.1	0.0	S4,Adult,Stat,Light,No
3	13	N	13	0.9	0.8	5.9	3.1	S1,Child,Walk,Light,Yes	1	34	N	35	1.5	1.1	8.4	0.0	S4,Adult,Stat,Light,No
3	13	N	13	0.9	0.7	5.5	3.1	S1,Child,Walk,Light,Yes	1	34	N	34	1.8	1.2	8.3	0.0	S4,Adult,Stat,Light,No
3	13	N	13	0.9	0.7	5.5	3.3	S1,Child,Walk,Light,Yes	1	9	N	10	1.3	0.7	6.3	0.0	S4,Adult,Stat,Light,No
3	15	N	15	0.8	0.7	6.9	3.1	S1,Child,Walk,Light,Yes	1	9	N	9	1.3	0.7	6.4	0.0	S4,Adult,Stat,Light,No
3	15	N	16	0.9	0.7	4.8	3.1	S1,Child,Walk,Light,Yes	1	9	N	9	1.3	0.7	6.2	0.0	S4,Adult,Stat,Light,No
3	16	N	16	0.9	0.8	6.6	3.1	S1,Child,Walk,Light,Yes	1	12	N	12	1.3	0.7	6.8	0.0	S4,Adult,Stat,Light,No
3	19	N	19	0.8	0.7	7.5	3.1	S1,Child,Walk,Light,Yes	1	13	N	13	1.3	0.6	6.9	0.0	S4,Adult,Stat,Light,No
3	19	N	19	0.8	0.7	7.3	3.1	S1,Child,Walk,Light,Yes	1	12	N	12	1.3	0.8	6.8	0.0	S4,Adult,Stat,Light,No
3	19	N	18	0.8	0.7	7.1	3.1	S1,Child,Walk,Light,Yes	1	15	N	15	1.3	0.7	7.1	0.0	S4,Adult,Stat,Light,No
3	4	Y	10	0.6	0.5	3.3	3.1	S1,Child,Walk,Light,Yes	1	15	N	16	1.4	0.7	6.6	0.0	S4,Adult,Stat,Light,No
3	2	Y	13	0.5	0.3	2.3	3.1	S1,Child,Walk,Light,Yes	1	15	N	16	0.8	0.6	7.4	0.0	S4,Adult,Stat,Light,No
3	5	Y	13	0.1	0.4	5.3	3.1	S1,Child,Walk,Light,Yes	1	18	N	19	1.5	0.8	7.3	0.0	S4,Adult,Stat,Light,No
3	2	Y	13	0.6	0.2	3.3	3.1	S1,Child,Walk,Light,Yes	1	18	N	18	1.5	0.8	7.2	0.0	S4,Adult,Stat,Light,No

OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)	OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)
1	18	N	19	1.5	0.8	7.2	0.0	S4,Adult,Stat,Light,No	1	9	N	10	1.3	0.6	6.4	0.0	S4,Adult,Stat,Light,No
1	21	N	22	1.7	1.0	7.4	0.0	S4,Adult,Stat,Light,No	1	9	N	9	1.3	0.7	6.4	0.0	S4,Adult,Stat,Light,No
1	22	N	22	1.7	1.0	7.7	0.0	S4,Adult,Stat,Light,No	1	10	N	9	1.4	0.6	6.4	0.0	S4,Adult,Stat,Light,No
1	25	N	25	1.7	1.0	7.8	0.0	S4,Adult,Stat,Light,No	1	12	N	13	1.3	0.6	6.7	0.0	S4,Adult,Stat,Light,No
1	24	N	25	1.6	1.1	7.6	0.0	S4,Adult,Stat,Light,No	1	12	N	12	1.2	0.7	6.5	0.0	S4,Adult,Stat,Light,No
1	25	N	25	1.6	1.1	7.7	0.0	S4,Adult,Stat,Light,No	1	12	N	13	1.2	0.6	6.8	0.0	S4,Adult,Stat,Light,No
1	28	N	28	1.6	1.0	7.6	0.0	S4,Adult,Stat,Light,No	1	15	N	15	1.2	0.8	6.9	0.0	S4,Adult,Stat,Light,No
1	28	N	28	1.7	1.1	6.4	0.0	S4,Adult,Stat,Light,No	1	16	N	15	1.5	0.8	7.1	0.0	S4,Adult,Stat,Light,No
1	28	N	28	1.5	1.2	5.9	0.0	S4,Adult,Stat,Light,No	1	18	N	18	1.6	0.8	7.3	0.0	S4,Adult,Stat,Light,No
1	31	N	31	1.7	1.0	8.0	0.0	S4,Adult,Stat,Light,No	1	18	N	19	1.6	0.8	7.2	0.0	S4,Adult,Stat,Light,No
1	31	N	31	1.8	1.0	8.1	0.0	S4,Adult,Stat,Light,No	1	18	N	19	1.6	0.8	7.4	0.0	S4,Adult,Stat,Light,No
1	30	N	31	1.5	1.1	6.8	0.0	S4,Adult,Stat,Light,No	1	22	N	22	1.5	0.8	7.4	0.0	S4,Adult,Stat,Light,No
1	34	N	34	1.4	1.0	8.3	0.0	S4,Adult,Stat,Light,No	1	21	N	22	1.6	0.9	7.6	0.0	S4,Adult,Stat,Light,No
1	35	N	35	1.7	1.1	6.7	0.0	S4,Adult,Stat,Light,No	1	22	N	22	1.6	0.9	7.5	0.0	S4,Adult,Stat,Light,No
1	38	N	38	1.4	1.2	8.3	0.0	S4,Adult,Stat,Light,No	1	24	N	25	1.2	1.1	7.9	0.0	S4,Adult,Stat,Light,No
1	37	N	38	1.8	1.1	8.2	0.0	S4,Adult,Stat,Light,No	1	25	N	25	1.6	1.0	7.7	0.0	S4,Adult,Stat,Light,No
1	9	N	9	1.3	0.5	6.4	0.0	S4,Adult,Stat,Light,No	1	27	N	28	1.6	1.1	7.9	0.0	S4,Adult,Stat,Light,No
1	9	N	9	1.4	0.6	6.7	0.0	S4,Adult,Stat,Light,No	1	28	N	28	1.5	0.9	7.7	0.0	S4,Adult,Stat,Light,No
1	10	N	10	1.3	0.7	6.4	0.0	S4,Adult,Stat,Light,No	1	9	N	9	1.1	0.6	6.4	0.0	S4,Adult,Stat,Light,No
1	13	N	13	1.1	0.6	7.2	0.0	S4,Adult,Stat,Light,No	1	9	N	9	1.1	0.6	6.1	0.0	S4,Adult,Stat,Light,No
1	13	N	13	1.2	0.7	7.2	0.0	S4,Adult,Stat,Light,No	1	9	N	10	1.2	0.6	6.3	0.0	S4,Adult,Stat,Light,No
1	12	N	13	1.3	0.7	6.9	0.0	S4,Adult,Stat,Light,No	1	13	N	13	1.2	0.6	7.1	0.0	S4,Adult,Stat,Light,No
1	16	N	15	1.4	0.6	7.1	0.0	S4,Adult,Stat,Light,No	1	12	N	12	1.2	0.6	6.7	0.0	S4,Adult,Stat,Light,No
1	15	N	16	1.0	0.6	7.3	0.0	S4,Adult,Stat,Light,No	1	12	N	12	1.2	0.6	6.7	0.0	S4,Adult,Stat,Light,No
1	18	N	19	1.6	0.9	7.3	0.0	S4,Adult,Stat,Light,No	1	16	N	15	1.5	0.6	7.1	0.0	S4,Adult,Stat,Light,No
1	18	N	18	1.2	0.6	7.7	0.0	S4,Adult,Stat,Light,No	1	16	N	16	1.3	0.7	7.3	0.0	S4,Adult,Stat,Light,No
1	25	N	26	0.8	0.8	8.1	0.0	S4,Adult,Stat,Light,No	1	15	N	15	1.2	0.7	7.2	0.0	S4,Adult,Stat,Light,No
1	25	N	25	1.4	0.8	7.9	0.0	S4,Adult,Stat,Light,No	1	19	N	19	1.7	0.7	7.5	0.0	S4,Adult,Stat,Light,No
1	25	N	25	1.3	1.0	7.7	0.0	S4,Adult,Stat,Light,No	1	19	N	18	1.5	0.7	7.3	0.0	S4,Adult,Stat,Light,No
1	28	N	28	1.3	0.9	8.2	0.0	S4,Adult,Stat,Light,No	1	19	N	19	1.5	0.8	7.4	0.0	S4,Adult,Stat,Light,No
1	32	N	31	1.7	1.2	7.8	0.0	S4,Adult,Stat,Light,No	1	21	N	22	1.3	0.8	7.9	0.0	S4,Adult,Stat,Light,No
1	31	N	31	1.7	1.1	7.9	0.0	S4,Adult,Stat,Light,No	1	22	N	22	1.5	0.7	7.8	0.0	S4,Adult,Stat,Light,No
1	31	N	31	1.7	1.0	8.4	0.0	S4,Adult,Stat,Light,No	1	25	N	24	1.6	1.2	6.7	0.0	S4,Adult,Stat,Light,No
1	9	N	9	4.0	0.7	6.4	0.0	S4,Adult,Stat,Light,No	1	25	N	25	1.6	1.0	8.0	0.0	S4,Adult,Stat,Light,No
1	9	N	9	1.2	0.7	6.3	0.0	S4,Adult,Stat,Light,No	1	28	N	28	1.7	1.1	8.1	0.0	S4,Adult,Stat,Light,No
1	9	N	10	1.3	0.6	6.5	0.0	S4,Adult,Stat,Light,No	1	29	N	28	1.6	1.0	8.4	0.0	S4,Adult,Stat,Light,No
1	12	N	12	1.2	0.7	6.7	0.0	S4,Adult,Stat,Light,No	1	32	N	31	1.7	1.1	7.0	0.0	S4,Adult,Stat,Light,No
1	12	N	12	1.3	0.6	6.6	0.0	S4,Adult,Stat,Light,No	1	31	N	31	1.7	1.0	8.4	0.0	S4,Adult,Stat,Light,No
1	12	N	13	1.2	0.7	6.6	0.0	S4,Adult,Stat,Light,No	1	31	N	31	1.7	1.0	8.4	0.0	S4,Adult,Stat,Light,No
1	15	N	15	1.5	0.7	7.0	0.0	S4,Adult,Stat,Light,No	1	35	N	34	1.8	1.1	8.4	0.0	S4,Adult,Stat,Light,No
1	15	N	16	1.4	0.6	7.2	0.0	S4,Adult,Stat,Light,No	1	34	N	34	1.2	1.1	8.5	0.0	S4,Adult,Stat,Light,No
1	16	N	16	1.4	0.7	7.0	0.0	S4,Adult,Stat,Light,No	1	34	N	35	1.3	1.0	8.5	0.0	S4,Adult,Stat,Light,No
1	19	N	19	1.6	1.0	6.8	0.0	S4,Adult,Stat,Light,No	1	38	N	38	1.8	1.1	8.6	0.0	S4,Adult,Stat,Light,No
1	19	N	19	1.6	0.9	7.5	0.0	S4,Adult,Stat,Light,No	1	37	N	37	1.9	1.1	8.7	0.0	S4,Adult,Stat,Light,No
1	19	N	19	1.4	0.8	7.3	0.0	S4,Adult,Stat,Light,No	1	37	N	37	1.8	1.0	8.9	0.0	S4,Adult,Stat,Light,No
1	22	N	22	1.6	0.9	7.5	0.0	S4,Adult,Stat,Light,No	1	15	Y	16	1.4	0.5	7.4	0.0	S4,Adult,Stat,Light,No
1	22	N	22	1.6	0.9	7.6	0.0	S4,Adult,Stat,Light,No	1	22	Y	25	0.8	0.7	7.7	0.0	S4,Adult,Stat,Light,No
1	22	N	22	1.6	1.0	7.4	0.0	S4,Adult,Stat,Light,No	1	14	Y	38	1.8	0.7	7.5	0.0	S4,Adult,Stat,Light,No
1	25	N	25	1.6	1.0	7.7	0.0	S4,Adult,Stat,Light,No	1	8	Y	21	0.5	0.4	7.9	0.0	S4,Adult,Stat,Light,No
1	25	N	25	1.7	1.1	6.5	0.0	S4,Adult,Stat,Light,No	1	17	Y	34	0.9	0.8	8.3	0.0	S4,Adult,Stat,Light,No

OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)	OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)
1	17	Y	38	0.9	0.8	8.2	0.0	S4,Adult,Stat,Light,No	2	16	N	16	2.2	1.3	3.9	0.0	S4,Adult,Stat,Light,No
1	11	Y	16	0.8	0.5	7.7	0.0	S4,Adult,Stat,Light,No	2	16	N	16	2.3	1.2	4.5	0.0	S4,Adult,Stat,Light,No
1	17	Y	19	1.6	0.6	7.5	0.0	S4,Adult,Stat,Light,No	2	16	N	16	2.2	1.4	3.8	0.0	S4,Adult,Stat,Light,No
1	2	Y	22	0.4	0.3	6.7	0.0	S4,Adult,Stat,Light,No	2	19	N	19	2.4	1.2	5.0	0.0	S4,Adult,Stat,Light,No
1	20	Y	22	1.6	0.7	7.6	0.0	S4,Adult,Stat,Light,No	2	19	N	19	2.4	1.5	4.2	0.0	S4,Adult,Stat,Light,No
1	9	Y	21	1.2	0.6	6.8	0.0	S4,Adult,Stat,Light,No	2	19	N	19	2.3	1.3	4.7	0.0	S4,Adult,Stat,Light,No
1	25	Y	28	1.7	1.0	6.5	0.0	S4,Adult,Stat,Light,No	2	22	N	22	2.4	1.7	4.3	0.0	S4,Adult,Stat,Light,No
1	25	Y	28	1.7	1.2	6.8	0.0	S4,Adult,Stat,Light,No	2	22	N	22	2.6	1.4	4.8	0.0	S4,Adult,Stat,Light,No
1	31	Y	34	1.2	1.1	6.7	0.0	S4,Adult,Stat,Light,No	2	23	N	23	2.6	2.2	3.6	0.0	S4,Adult,Stat,Light,No
1	18	Y	35	1.4	1.0	7.7	0.0	S4,Adult,Stat,Light,No	2	25	N	25	2.6	1.6	4.5	0.0	S4,Adult,Stat,Light,No
1	12	Y	34	1.3	1.0	6.0	0.0	S4,Adult,Stat,Light,No	2	25	N	25	2.5	1.6	4.8	0.0	S4,Adult,Stat,Light,No
1	10	Y	25	1.3	0.5	7.8	0.0	S4,Adult,Stat,Light,No	2	25	N	25	2.5	1.7	4.4	0.0	S4,Adult,Stat,Light,No
1	12	Y	15	1.2	0.5	7.1	0.0	S4,Adult,Stat,Light,No	2	28	N	28	2.7	1.9	4.2	0.0	S4,Adult,Stat,Light,No
1	18	Y	25	0.8	0.7	7.7	0.0	S4,Adult,Stat,Light,No	2	28	N	28	2.4	1.8	4.5	0.0	S4,Adult,Stat,Light,No
1	16	Y	28	1.5	0.7	7.8	0.0	S4,Adult,Stat,Light,No	2	28	N	28	2.6	1.6	4.6	0.0	S4,Adult,Stat,Light,No
1	20	Y	31	1.3	0.8	8.0	0.0	S4,Adult,Stat,Light,No	2	32	N	31	2.5	1.8	4.8	0.0	S4,Adult,Stat,Light,No
1	0	Y	31	1.3	0.0	0.0	0.0	S4,Adult,Stat,Light,No	2	31	N	31	2.5	1.7	5.2	0.0	S4,Adult,Stat,Light,No
1	9	Y	22	1.6	0.6	7.0	0.0	S4,Adult,Stat,Light,No	2	31	N	31	2.9	2.1	4.4	0.0	S4,Adult,Stat,Light,No
1	25	Y	28	1.7	1.1	6.5	0.0	S4,Adult,Stat,Light,No	2	34	N	34	2.0	1.4	6.5	0.0	S4,Adult,Stat,Light,No
2	9	N	9	1.3	0.9	3.7	0.0	S4,Adult,Stat,Light,No	2	34	N	34	2.1	1.6	5.8	0.0	S4,Adult,Stat,Light,No
2	9	N	9	1.2	0.7	4.9	0.0	S4,Adult,Stat,Light,No	2	34	N	34	2.2	1.5	6.2	0.0	S4,Adult,Stat,Light,No
2	9	N	9	1.5	0.8	4.5	0.0	S4,Adult,Stat,Light,No	2	38	N	38	2.0	1.5	7.0	0.0	S4,Adult,Stat,Light,No
2	12	N	13	1.2	0.9	4.7	0.0	S4,Adult,Stat,Light,No	2	37	N	37	1.9	1.5	6.6	0.0	S4,Adult,Stat,Light,No
2	12	N	13	1.1	0.9	4.7	0.0	S4,Adult,Stat,Light,No	2	38	N	38	1.9	1.4	7.2	0.0	S4,Adult,Stat,Light,No
2	12	N	13	1.2	0.9	4.7	0.0	S4,Adult,Stat,Light,No	2	13	N	13	1.4	1.0	4.2	0.0	S4,Adult,Stat,Light,No
2	16	N	16	1.6	1.1	4.6	0.0	S4,Adult,Stat,Light,No	2	6	Y	34	2.1	0.6	5.8	0.0	S4,Adult,Stat,Light,No
2	15	N	15	1.8	1.0	5.1	0.0	S4,Adult,Stat,Light,No	2	0	Y	10	1.1	0.0	0.0	0.0	S4,Adult,Stat,Light,No
2	15	N	15	1.4	1.0	4.9	0.0	S4,Adult,Stat,Light,No	2	0	Y	10	1.1	0.0	0.0	0.0	S4,Adult,Stat,Light,No
2	19	N	19	1.6	1.1	5.1	0.0	S4,Adult,Stat,Light,No	2	1	Y	13	1.1	0.7	2.7	0.0	S4,Adult,Stat,Light,No
2	19	N	19	1.5	1.1	4.8	0.0	S4,Adult,Stat,Light,No	2	0	Y	12	1.1	0.0	0.0	0.0	S4,Adult,Stat,Light,No
2	19	N	19	1.9	1.2	4.7	0.0	S4,Adult,Stat,Light,No	2	0	Y	13	1.1	0.0	0.0	0.0	S4,Adult,Stat,Light,No
2	22	N	22	2.2	1.4	4.9	0.0	S4,Adult,Stat,Light,No	2	0	Y	16	0.9	0.0	0.0	0.0	S4,Adult,Stat,Light,No
2	22	N	22	1.8	1.3	4.9	0.0	S4,Adult,Stat,Light,No	2	4	Y	16	1.4	1.2	3.8	0.0	S4,Adult,Stat,Light,No
2	22	N	21	1.6	1.3	5.1	0.0	S4,Adult,Stat,Light,No	2	1	Y	16	0.9	0.0	2.5	0.0	S4,Adult,Stat,Light,No
2	25	N	25	2.3	1.3	5.0	0.0	S4,Adult,Stat,Light,No	2	5	Y	19	1.5	0.9	5.1	0.0	S4,Adult,Stat,Light,No
2	25	N	25	1.7	1.3	5.2	0.0	S4,Adult,Stat,Light,No	2	1	Y	19	0.9	0.8	1.9	0.0	S4,Adult,Stat,Light,No
2	25	N	25	2.0	1.4	5.1	0.0	S4,Adult,Stat,Light,No	2	5	Y	19	1.6	0.8	5.3	0.0	S4,Adult,Stat,Light,No
2	28	N	28	2.7	1.5	5.0	0.0	S4,Adult,Stat,Light,No	2	0	Y	22	0.9	0.0	0.0	0.0	S4,Adult,Stat,Light,No
2	28	N	28	2.2	1.4	4.9	0.0	S4,Adult,Stat,Light,No	2	0	Y	9	1.0	0.0	0.0	0.0	S4,Adult,Stat,Light,No
2	28	N	28	2.8	1.5	5.0	0.0	S4,Adult,Stat,Light,No	2	0	Y	10	1.0	0.0	0.0	0.0	S4,Adult,Stat,Light,No
2	31	N	31	2.8	1.6	5.2	0.0	S4,Adult,Stat,Light,No	2	0	Y	9	1.0	0.0	0.0	0.0	S4,Adult,Stat,Light,No
2	31	N	31	2.8	1.6	5.1	0.0	S4,Adult,Stat,Light,No	2	0	Y	13	1.0	0.0	0.0	0.0	S4,Adult,Stat,Light,No
2	31	N	31	2.4	1.7	4.8	0.0	S4,Adult,Stat,Light,No	2	0	Y	12	1.1	0.3	3.9	0.0	S4,Adult,Stat,Light,No
2	10	N	10	1.6	0.8	4.1	0.0	S4,Adult,Stat,Light,No	2	3	Y	15	1.4	0.7	4.8	0.0	S4,Adult,Stat,Light,No
2	9	N	9	1.8	0.9	4.1	0.0	S4,Adult,Stat,Light,No	2	2	Y	16	1.4	0.7	4.6	0.0	S4,Adult,Stat,Light,No
2	9	N	9	1.9	0.8	4.1	0.0	S4,Adult,Stat,Light,No	2	3	Y	16	1.4	0.4	6.1	0.0	S4,Adult,Stat,Light,No
2	10	N	9	1.8	0.8	4.5	0.0	S4,Adult,Stat,Light,No	2	9	Y	19	1.6	0.9	5.4	0.0	S4,Adult,Stat,Light,No
2	13	N	12	1.8	1.1	3.8	0.0	S4,Adult,Stat,Light,No	2	1	Y	19	0.9	0.0	2.8	0.0	S4,Adult,Stat,Light,No
2	13	N	13	1.8	1.1	4.1	0.0	S4,Adult,Stat,Light,No	2	8	Y	19	1.7	0.9	5.4	0.0	S4,Adult,Stat,Light,No
2	12	N	12	1.9	1.0	4.3	0.0	S4,Adult,Stat,Light,No	2	0	Y	22	1.0	0.0	0.0	0.0	S4,Adult,Stat,Light,No

OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)	OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)
2	0	Y	22	1.0	0.0	0.0	0.0	S4,Adult,Stat,Light,No	3	15	N	16	1.6	0.9	6.0	0.0	S4,Adult,Stat,Light,No
2	0	Y	10	1.0	0.0	0.0	0.0	S4,Adult,Stat,Light,No	3	16	N	15	1.6	0.9	5.6	0.0	S4,Adult,Stat,Light,No
2	0	Y	9	1.0	0.0	0.0	0.0	S4,Adult,Stat,Light,No	3	19	N	19	1.7	1.2	4.1	0.0	S4,Adult,Stat,Light,No
2	0	Y	9	1.0	0.0	0.0	0.0	S4,Adult,Stat,Light,No	3	19	N	19	1.6	1.1	4.5	0.0	S4,Adult,Stat,Light,No
2	0	Y	13	1.1	0.0	0.0	0.0	S4,Adult,Stat,Light,No	3	19	N	19	1.5	1.1	4.5	0.0	S4,Adult,Stat,Light,No
2	0	Y	12	1.0	0.0	0.0	0.0	S4,Adult,Stat,Light,No	3	22	N	22	1.6	1.1	6.5	0.0	S4,Adult,Stat,Light,No
2	0	Y	12	1.1	0.0	0.0	0.0	S4,Adult,Stat,Light,No	3	22	N	22	1.6	1.2	6.2	0.0	S4,Adult,Stat,Light,No
2	3	Y	16	1.4	0.4	5.9	0.0	S4,Adult,Stat,Light,No	3	22	N	22	1.6	1.1	6.6	0.0	S4,Adult,Stat,Light,No
2	1	Y	15	1.3	0.4	5.0	0.0	S4,Adult,Stat,Light,No	3	24	N	25	1.6	1.1	6.4	0.0	S4,Adult,Stat,Light,No
2	3	Y	16	1.4	0.7	5.1	0.0	S4,Adult,Stat,Light,No	3	25	N	25	1.6	1.2	6.5	0.0	S4,Adult,Stat,Light,No
2	11	Y	19	1.7	0.9	5.6	0.0	S4,Adult,Stat,Light,No	3	25	N	25	1.6	1.1	6.7	0.0	S4,Adult,Stat,Light,No
2	0	Y	19	1.0	0.0	4.0	0.0	S4,Adult,Stat,Light,No	3	28	N	28	1.6	1.3	6.6	0.0	S4,Adult,Stat,Light,No
2	4	Y	19	1.5	0.4	6.2	0.0	S4,Adult,Stat,Light,No	3	28	N	28	1.6	1.2	6.2	0.0	S4,Adult,Stat,Light,No
2	9	Y	22	1.8	1.0	5.3	0.0	S4,Adult,Stat,Light,No	3	32	N	32	1.4	1.2	6.6	0.0	S4,Adult,Stat,Light,No
2	0	Y	22	0.8	0.0	0.0	0.0	S4,Adult,Stat,Light,No	3	11	N	31	1.2	1.0	5.5	0.0	S4,Adult,Stat,Light,No
2	0	Y	22	0.9	0.0	0.0	0.0	S4,Adult,Stat,Light,No	3	10	N	10	1.5	0.8	5.1	0.0	S4,Adult,Stat,Light,No
3	10	N	10	1.5	0.8	5.2	0.0	S4,Adult,Stat,Light,No	3	12	N	13	1.6	0.8	5.7	0.0	S4,Adult,Stat,Light,No
3	9	N	9	1.5	0.8	5.1	0.0	S4,Adult,Stat,Light,No	3	12	N	13	1.5	0.8	5.6	0.0	S4,Adult,Stat,Light,No
3	10	N	10	1.5	0.8	5.2	0.0	S4,Adult,Stat,Light,No	3	12	N	12	1.4	0.8	5.7	0.0	S4,Adult,Stat,Light,No
3	12	N	12	1.6	1.0	4.9	0.0	S4,Adult,Stat,Light,No	3	16	N	16	1.4	0.9	4.7	0.0	S4,Adult,Stat,Light,No
3	12	N	12	1.5	0.8	5.6	0.0	S4,Adult,Stat,Light,No	3	16	N	15	1.6	0.9	5.9	0.0	S4,Adult,Stat,Light,No
3	13	N	13	1.5	0.8	5.8	0.0	S4,Adult,Stat,Light,No	3	16	N	15	1.6	0.9	6.1	0.0	S4,Adult,Stat,Light,No
3	16	N	15	1.6	0.9	6.2	0.0	S4,Adult,Stat,Light,No	3	18	N	18	1.7	1.0	6.1	0.0	S4,Adult,Stat,Light,No
3	16	N	16	1.6	0.9	5.8	0.0	S4,Adult,Stat,Light,No	3	18	N	18	1.5	1.1	4.6	0.0	S4,Adult,Stat,Light,No
3	15	N	16	1.6	1.0	4.5	0.0	S4,Adult,Stat,Light,No	3	0	N	18	0.2	0.0	6.1	0.0	S4,Adult,Stat,Light,No
3	19	N	19	1.6	1.1	4.5	0.0	S4,Adult,Stat,Light,No	3	0	N	21	0.0	0.0	0.0	0.0	S4,Adult,Stat,Light,No
3	19	N	19	1.4	1.0	6.0	0.0	S4,Adult,Stat,Light,No	3	9	N	9	1.5	0.7	5.2	0.0	S4,Adult,Stat,Light,No
3	19	N	19	1.6	1.1	4.7	0.0	S4,Adult,Stat,Light,No	3	9	N	9	1.5	0.8	5.2	0.0	S4,Adult,Stat,Light,No
3	21	N	22	1.6	1.1	5.5	0.0	S4,Adult,Stat,Light,No	3	9	N	9	1.5	0.8	4.9	0.0	S4,Adult,Stat,Light,No
3	22	N	22	1.6	1.1	6.1	0.0	S4,Adult,Stat,Light,No	3	13	N	13	1.6	0.8	5.5	0.0	S4,Adult,Stat,Light,No
3	22	N	22	1.6	1.2	5.4	0.0	S4,Adult,Stat,Light,No	3	13	N	13	1.6	0.9	5.3	0.0	S4,Adult,Stat,Light,No
3	25	N	25	1.6	1.1	6.6	0.0	S4,Adult,Stat,Light,No	3	13	N	13	1.6	0.8	5.7	0.0	S4,Adult,Stat,Light,No
3	25	N	25	1.6	1.2	5.9	0.0	S4,Adult,Stat,Light,No	3	16	N	16	1.5	0.9	5.8	0.0	S4,Adult,Stat,Light,No
3	25	N	25	1.6	1.3	6.3	0.0	S4,Adult,Stat,Light,No	3	16	N	16	1.6	1.0	5.8	0.0	S4,Adult,Stat,Light,No
3	28	N	28	1.6	1.2	6.6	0.0	S4,Adult,Stat,Light,No	3	16	N	16	1.6	0.9	5.9	0.0	S4,Adult,Stat,Light,No
3	28	N	29	1.4	1.3	6.6	0.0	S4,Adult,Stat,Light,No	3	19	N	18	1.6	1.1	4.9	0.0	S4,Adult,Stat,Light,No
3	28	N	28	1.6	1.3	6.5	0.0	S4,Adult,Stat,Light,No	3	19	N	19	1.6	1.1	4.7	0.0	S4,Adult,Stat,Light,No
3	31	N	32	1.3	1.3	6.5	0.0	S4,Adult,Stat,Light,No	3	19	N	19	1.6	1.1	5.9	0.0	S4,Adult,Stat,Light,No
3	31	N	31	1.6	1.3	6.6	0.0	S4,Adult,Stat,Light,No	3	22	N	22	1.3	1.1	6.6	0.0	S4,Adult,Stat,Light,No
3	31	N	31	1.6	1.3	6.5	0.0	S4,Adult,Stat,Light,No	3	22	N	22	1.5	1.1	6.4	0.0	S4,Adult,Stat,Light,No
3	34	N	35	1.5	1.3	6.5	0.0	S4,Adult,Stat,Light,No	3	22	N	22	1.4	1.1	6.4	0.0	S4,Adult,Stat,Light,No
3	35	N	35	1.6	1.3	6.6	0.0	S4,Adult,Stat,Light,No	3	25	N	25	1.6	1.1	6.7	0.0	S4,Adult,Stat,Light,No
3	34	N	35	1.5	1.3	6.8	0.0	S4,Adult,Stat,Light,No	3	25	N	25	1.6	1.1	7.0	0.0	S4,Adult,Stat,Light,No
3	30	N	38	1.4	1.3	7.1	0.0	S4,Adult,Stat,Light,No	3	25	N	25	1.6	1.1	6.8	0.0	S4,Adult,Stat,Light,No
3	9	N	9	1.5	0.8	3.6	0.0	S4,Adult,Stat,Light,No	3	28	N	29	1.5	1.2	6.7	0.0	S4,Adult,Stat,Light,No
3	9	N	9	1.5	0.8	5.0	0.0	S4,Adult,Stat,Light,No	3	28	N	28	1.6	1.2	6.7	0.0	S4,Adult,Stat,Light,No
3	13	N	13	1.6	0.9	5.3	0.0	S4,Adult,Stat,Light,No	3	28	N	28	1.6	1.2	6.8	0.0	S4,Adult,Stat,Light,No
3	12	N	12	1.5	0.9	5.4	0.0	S4,Adult,Stat,Light,No	3	31	N	31	1.6	1.3	6.4	0.0	S4,Adult,Stat,Light,No
3	12	N	13	1.6	0.9	5.5	0.0	S4,Adult,Stat,Light,No	3	31	N	31	1.6	1.3	6.7	0.0	S4,Adult,Stat,Light,No
3	16	N	16	1.6	1.0	5.5	0.0	S4,Adult,Stat,Light,No	3	31	N	31	1.6	1.3	6.4	0.0	S4,Adult,Stat,Light,No

OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)	OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)
3	34	N	35	1.6	1.3	6.9	0.0	S4,Adult,Stat,Light,No	3	27	N	28	1.6	1.2	6.9	0.0	S4,Adult,Stat,Light,No
3	34	N	35	1.3	1.2	6.9	0.0	S4,Adult,Stat,Light,No	3	31	N	31	1.4	1.2	6.7	0.0	S4,Adult,Stat,Light,No
3	34	N	35	1.6	1.3	6.5	0.0	S4,Adult,Stat,Light,No	3	32	N	32	1.4	1.2	6.4	0.0	S4,Adult,Stat,Light,No
3	9	N	10	1.5	0.8	5.1	0.0	S4,Adult,Stat,Light,No	3	31	N	31	1.5	1.3	6.4	0.0	S4,Adult,Stat,Light,No
3	9	N	9	1.5	0.9	4.4	0.0	S4,Adult,Stat,Light,No	3	30	Y	38	1.4	1.3	7.1	0.0	S4,Adult,Stat,Light,No
3	9	N	9	1.5	0.8	5.1	0.0	S4,Adult,Stat,Light,No	3	27	Y	38	2.1	1.2	5.7	0.0	S4,Adult,Stat,Light,No
3	13	N	13	1.5	0.8	5.8	0.0	S4,Adult,Stat,Light,No	3	9	Y	9	1.5	0.8	4.9	0.0	S4,Adult,Stat,Light,No
3	12	N	12	1.6	0.8	5.5	0.0	S4,Adult,Stat,Light,No	3	9	Y	10	1.5	0.8	5.2	0.0	S4,Adult,Stat,Light,No
3	12	N	12	1.6	0.8	5.6	0.0	S4,Adult,Stat,Light,No	3	22	Y	22	1.4	1.1	6.2	0.0	S4,Adult,Stat,Light,No
3	16	N	16	1.6	0.9	5.9	0.0	S4,Adult,Stat,Light,No	3	16	Y	37	1.3	1.2	6.6	0.0	S4,Adult,Stat,Light,No
3	15	N	15	1.6	0.9	5.9	0.0	S4,Adult,Stat,Light,No	3	23	Y	37	1.1	1.0	6.9	0.0	S4,Adult,Stat,Light,No
3	16	N	16	1.7	1.0	5.9	0.0	S4,Adult,Stat,Light,No	3	29	Y	38	1.3	1.2	5.8	0.0	S4,Adult,Stat,Light,No
3	19	N	19	1.6	1.1	4.7	0.0	S4,Adult,Stat,Light,No	3	29	Y	37	1.3	1.3	6.5	0.0	S4,Adult,Stat,Light,No
3	19	N	19	1.5	1.1	4.7	0.0	S4,Adult,Stat,Light,No	3	25	Y	37	1.2	1.1	6.9	0.0	S4,Adult,Stat,Light,No
3	19	N	19	1.6	1.1	4.7	0.0	S4,Adult,Stat,Light,No	3	28	Y	37	1.3	1.2	6.5	0.0	S4,Adult,Stat,Light,No
3	22	N	22	1.5	1.1	6.4	0.0	S4,Adult,Stat,Light,No	3	17	Y	34	1.5	1.2	4.7	0.0	S4,Adult,Stat,Light,No
3	22	N	22	1.5	1.1	6.3	0.0	S4,Adult,Stat,Light,No	3	11	Y	34	1.4	1.0	6.3	0.0	S4,Adult,Stat,Light,No
3	22	N	22	1.6	1.1	6.4	0.0	S4,Adult,Stat,Light,No	1	10	N	10	1.3	0.5	7.0	3.1	S4,Adult,Walk+,Light,No
3	25	N	25	1.4	1.1	6.6	0.0	S4,Adult,Stat,Light,No	1	9	N	10	1.4	0.6	7.0	3.1	S4,Adult,Walk+,Light,No
3	25	N	25	1.6	1.1	6.4	0.0	S4,Adult,Stat,Light,No	1	10	N	10	1.3	0.4	6.7	3.1	S4,Adult,Walk+,Light,No
3	25	N	25	1.4	1.1	6.6	0.0	S4,Adult,Stat,Light,No	1	9	N	10	1.4	0.5	7.1	3.1	S4,Adult,Walk+,Light,No
3	28	N	28	1.6	1.3	6.6	0.0	S4,Adult,Stat,Light,No	1	9	N	10	1.4	0.8	6.0	3.1	S4,Adult,Walk+,Light,No
3	27	N	28	1.6	1.2	6.8	0.0	S4,Adult,Stat,Light,No	1	9	N	10	1.4	0.3	6.5	3.1	S4,Adult,Walk+,Light,No
3	28	N	28	1.6	1.2	6.6	0.0	S4,Adult,Stat,Light,No	1	9	N	10	1.0	0.4	7.1	3.1	S4,Adult,Walk+,Light,No
3	32	N	31	1.5	1.3	6.4	0.0	S4,Adult,Stat,Light,No	1	9	N	9	1.1	0.3	7.1	3.1	S4,Adult,Walk+,Light,No
3	31	N	32	1.4	1.3	6.3	0.0	S4,Adult,Stat,Light,No	1	13	N	13	1.2	0.8	7.3	3.1	S4,Adult,Walk+,Light,No
3	31	N	31	1.6	1.2	6.4	0.0	S4,Adult,Stat,Light,No	1	13	N	13	1.1	0.5	7.4	3.1	S4,Adult,Walk+,Light,No
3	34	N	35	1.5	1.3	6.7	0.0	S4,Adult,Stat,Light,No	1	12	N	13	1.3	0.6	7.2	3.1	S4,Adult,Walk+,Light,No
3	34	N	34	1.5	1.3	6.4	0.0	S4,Adult,Stat,Light,No	1	12	N	12	1.1	0.4	7.4	3.1	S4,Adult,Walk+,Light,No
3	34	N	35	1.5	1.3	6.5	0.0	S4,Adult,Stat,Light,No	1	12	N	12	1.3	0.6	6.8	3.1	S4,Adult,Walk+,Light,No
3	10	N	10	1.5	0.8	4.8	0.0	S4,Adult,Stat,Light,No	1	16	N	15	1.3	0.7	7.2	3.1	S4,Adult,Walk+,Light,No
3	9	N	9	1.5	0.7	5.5	0.0	S4,Adult,Stat,Light,No	1	15	N	16	1.3	0.7	7.4	3.1	S4,Adult,Walk+,Light,No
3	9	N	10	1.5	0.8	5.0	0.0	S4,Adult,Stat,Light,No	1	16	N	16	1.3	0.6	7.3	3.1	S4,Adult,Walk+,Light,No
3	12	N	12	1.6	0.8	5.8	0.0	S4,Adult,Stat,Light,No	1	15	N	16	1.4	0.6	7.3	3.1	S4,Adult,Walk+,Light,No
3	12	N	11	1.5	0.8	5.7	0.0	S4,Adult,Stat,Light,No	1	16	N	16	1.3	0.7	7.2	3.1	S4,Adult,Walk+,Light,No
3	12	N	12	1.5	0.8	5.7	0.0	S4,Adult,Stat,Light,No	1	15	N	16	1.3	0.7	7.4	3.1	S4,Adult,Walk+,Light,No
3	15	N	17	1.6	1.0	4.1	0.0	S4,Adult,Stat,Light,No	1	19	N	19	1.4	0.8	7.3	3.1	S4,Adult,Walk+,Light,No
3	16	N	16	1.6	1.0	6.1	0.0	S4,Adult,Stat,Light,No	1	19	N	19	1.4	0.7	7.5	3.1	S4,Adult,Walk+,Light,No
3	15	N	15	1.6	0.9	6.0	0.0	S4,Adult,Stat,Light,No	1	18	N	19	1.3	0.8	7.4	3.1	S4,Adult,Walk+,Light,No
3	18	N	18	1.6	1.0	6.5	0.0	S4,Adult,Stat,Light,No	1	19	N	19	1.4	0.8	7.6	3.1	S4,Adult,Walk+,Light,No
3	18	N	18	1.6	1.0	6.4	0.0	S4,Adult,Stat,Light,No	1	18	N	18	1.4	0.8	7.2	3.1	S4,Adult,Walk+,Light,No
3	18	N	18	1.7	1.3	3.8	0.0	S4,Adult,Stat,Light,No	1	22	N	22	1.6	0.9	8.0	3.1	S4,Adult,Walk+,Light,No
3	21	N	21	1.6	1.1	6.3	0.0	S4,Adult,Stat,Light,No	1	22	N	22	1.6	0.9	7.8	3.1	S4,Adult,Walk+,Light,No
3	21	N	21	1.5	1.1	6.6	0.0	S4,Adult,Stat,Light,No	1	22	N	22	1.2	0.9	7.5	3.1	S4,Adult,Walk+,Light,No
3	22	N	21	1.5	1.1	6.6	0.0	S4,Adult,Stat,Light,No	1	22	N	22	1.5	0.9	7.7	3.1	S4,Adult,Walk+,Light,No
3	25	N	25	1.6	1.1	7.1	0.0	S4,Adult,Stat,Light,No	1	21	N	22	1.5	0.8	7.6	3.1	S4,Adult,Walk+,Light,No
3	24	N	26	1.6	1.3	6.3	0.0	S4,Adult,Stat,Light,No	1	21	N	22	1.4	0.9	7.7	3.1	S4,Adult,Walk+,Light,No
3	25	N	24	1.4	1.1	6.8	0.0	S4,Adult,Stat,Light,No	1	25	N	25	1.3	0.9	8.0	3.1	S4,Adult,Walk+,Light,No
3	28	N	28	1.5	1.2	6.9	0.0	S4,Adult,Stat,Light,No	1	25	N	25	1.5	0.8	8.0	3.1	S4,Adult,Walk+,Light,No
3	28	N	28	1.6	1.2	6.9	0.0	S4,Adult,Stat,Light,No	1	25	N	25	1.6	0.9	7.8	3.1	S4,Adult,Walk+,Light,No

OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s²)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)	OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s²)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)
1	5	Y	9	1.1	0.3	7.0	3.1	S4,Adult,Walk+,Light,No	2	22	N	22	2.3	1.8	4.1	3.1	S4,Adult,Walk+,Light,No
1	0	Y	13	0.4	0.0	0.0	3.1	S4,Adult,Walk+,Light,No	2	22	N	22	1.9	1.3	5.2	3.1	S4,Adult,Walk+,Light,No
1	2	Y	12	1.2	0.4	1.9	3.1	S4,Adult,Walk+,Light,No	2	25	N	26	1.8	1.4	5.2	3.1	S4,Adult,Walk+,Light,No
1	5	Y	12	1.2	0.3	7.8	3.2	S4,Adult,Walk+,Light,No	2	25	N	25	1.8	1.3	5.5	3.1	S4,Adult,Walk+,Light,No
1	5	Y	12	1.1	0.3	7.7	3.1	S4,Adult,Walk+,Light,No	2	25	N	25	1.8	1.3	5.3	3.1	S4,Adult,Walk+,Light,No
1	4	Y	15	1.2	0.3	7.0	3.2	S4,Adult,Walk+,Light,No	2	28	N	28	1.9	1.4	4.9	3.1	S4,Adult,Walk+,Light,No
1	6	Y	16	1.3	0.4	8.1	3.2	S4,Adult,Walk+,Light,No	2	28	N	29	2.0	1.4	5.2	3.1	S4,Adult,Walk+,Light,No
1	0	Y	16	1.3	0.0	0.0	3.1	S4,Adult,Walk+,Light,No	2	28	N	28	2.1	1.7	4.9	3.1	S4,Adult,Walk+,Light,No
1	0	Y	19	0.1	0.0	0.0	3.1	S4,Adult,Walk+,Light,No	2	30	N	31	2.1	1.6	4.9	3.1	S4,Adult,Walk+,Light,No
1	0	Y	25	0.0	0.0	0.0	3.1	S4,Adult,Walk+,Light,No	2	30	N	31	1.9	1.4	5.4	3.1	S4,Adult,Walk+,Light,No
1	0	Y	28	0.0	0.0	0.0	3.1	S4,Adult,Walk+,Light,No	2	30	N	32	2.2	1.6	4.9	3.1	S4,Adult,Walk+,Light,No
2	9	N	9	1.4	0.6	4.7	3.1	S4,Adult,Walk+,Light,No	2	33	N	35	1.8	1.4	5.9	3.1	S4,Adult,Walk+,Light,No
2	9	N	9	1.5	0.7	4.2	3.1	S4,Adult,Walk+,Light,No	2	34	N	34	1.9	1.3	6.5	3.1	S4,Adult,Walk+,Light,No
2	9	N	9	1.4	0.6	4.7	3.1	S4,Adult,Walk+,Light,No	2	30	N	35	2.1	1.4	5.5	3.1	S4,Adult,Walk+,Light,No
2	12	N	13	1.7	0.7	4.6	3.1	S4,Adult,Walk+,Light,No	2	37	N	37	2.4	1.9	5.3	3.1	S4,Adult,Walk+,Light,No
2	12	N	13	1.6	0.8	4.6	3.1	S4,Adult,Walk+,Light,No	2	37	N	37	1.7	1.4	6.8	3.1	S4,Adult,Walk+,Light,No
2	13	N	13	1.6	0.7	5.4	3.1	S4,Adult,Walk+,Light,No	2	36	N	37	1.5	1.3	6.6	3.1	S4,Adult,Walk+,Light,No
2	16	N	16	1.6	1.0	5.3	3.1	S4,Adult,Walk+,Light,No	2	9	N	9	1.5	0.7	4.1	3.1	S4,Adult,Walk+,Light,No
2	16	N	16	1.5	0.9	5.6	3.1	S4,Adult,Walk+,Light,No	2	9	N	10	1.6	0.7	4.5	3.1	S4,Adult,Walk+,Light,No
2	16	N	16	1.4	0.9	5.8	3.1	S4,Adult,Walk+,Light,No	2	9	N	9	1.4	0.5	5.0	3.1	S4,Adult,Walk+,Light,No
2	18	N	19	1.8	1.0	5.9	3.1	S4,Adult,Walk+,Light,No	2	12	N	13	1.3	0.9	4.5	3.1	S4,Adult,Walk+,Light,No
2	18	N	19	2.3	1.0	5.4	3.1	S4,Adult,Walk+,Light,No	2	13	N	12	1.3	0.9	4.3	3.1	S4,Adult,Walk+,Light,No
2	19	N	19	2.1	1.0	5.4	3.1	S4,Adult,Walk+,Light,No	2	12	N	12	1.4	0.9	4.5	3.1	S4,Adult,Walk+,Light,No
2	22	N	22	2.4	1.1	6.1	3.1	S4,Adult,Walk+,Light,No	2	16	N	16	1.2	0.9	5.7	3.1	S4,Adult,Walk+,Light,No
2	22	N	22	2.3	1.1	5.9	3.1	S4,Adult,Walk+,Light,No	2	15	N	16	1.1	1.1	4.8	3.1	S4,Adult,Walk+,Light,No
2	22	N	22	2.4	1.2	5.7	3.1	S4,Adult,Walk+,Light,No	2	15	N	16	1.6	1.0	5.2	3.1	S4,Adult,Walk+,Light,No
2	25	N	25	2.1	1.2	6.1	3.1	S4,Adult,Walk+,Light,No	2	19	N	19	1.9	1.4	4.3	3.1	S4,Adult,Walk+,Light,No
2	25	N	25	2.3	1.3	5.8	3.1	S4,Adult,Walk+,Light,No	2	18	N	18	1.7	1.1	5.2	3.1	S4,Adult,Walk+,Light,No
2	25	N	25	2.6	1.3	5.3	3.1	S4,Adult,Walk+,Light,No	2	18	N	19	1.8	0.9	6.3	3.1	S4,Adult,Walk+,Light,No
2	28	N	29	2.8	1.3	5.9	3.1	S4,Adult,Walk+,Light,No	2	22	N	22	2.1	1.2	5.5	3.1	S4,Adult,Walk+,Light,No
2	28	N	28	3.3	1.4	5.4	3.1	S4,Adult,Walk+,Light,No	2	22	N	22	1.9	1.3	5.1	3.1	S4,Adult,Walk+,Light,No
2	27	N	28	2.2	1.3	5.2	3.1	S4,Adult,Walk+,Light,No	2	22	N	22	2.0	1.3	5.0	3.1	S4,Adult,Walk+,Light,No
2	31	N	31	2.6	1.4	5.5	3.1	S4,Adult,Walk+,Light,No	2	25	N	25	2.2	1.6	4.9	3.1	S4,Adult,Walk+,Light,No
2	30	N	31	2.5	1.4	5.5	3.1	S4,Adult,Walk+,Light,No	2	25	N	25	2.1	1.6	4.6	3.1	S4,Adult,Walk+,Light,No
2	30	N	31	2.2	1.4	5.5	3.1	S4,Adult,Walk+,Light,No	2	25	N	25	2.2	1.6	4.7	3.1	S4,Adult,Walk+,Light,No
2	33	N	34	2.6	1.4	5.8	3.1	S4,Adult,Walk+,Light,No	2	28	N	28	2.2	1.4	5.5	3.1	S4,Adult,Walk+,Light,No
2	34	N	35	2.4	1.2	6.4	3.1	S4,Adult,Walk+,Light,No	2	28	N	28	2.0	1.4	5.3	3.1	S4,Adult,Walk+,Light,No
2	8	N	9	1.4	0.6	4.5	3.1	S4,Adult,Walk+,Light,No	2	28	N	28	2.1	1.5	4.9	3.1	S4,Adult,Walk+,Light,No
2	9	N	9	1.5	0.6	4.7	3.1	S4,Adult,Walk+,Light,No	2	31	N	32	1.6	1.3	6.0	3.1	S4,Adult,Walk+,Light,No
2	10	N	9	1.5	0.6	4.2	3.1	S4,Adult,Walk+,Light,No	2	31	N	31	1.7	1.4	6.3	3.1	S4,Adult,Walk+,Light,No
2	12	N	12	1.8	0.9	4.0	3.1	S4,Adult,Walk+,Light,No	2	31	N	31	2.7	1.8	4.6	3.1	S4,Adult,Walk+,Light,No
2	12	N	13	1.5	0.7	4.8	3.1	S4,Adult,Walk+,Light,No	2	34	N	34	1.4	1.3	6.9	3.1	S4,Adult,Walk+,Light,No
2	12	N	13	1.5	0.8	4.5	3.1	S4,Adult,Walk+,Light,No	2	34	N	34	1.7	1.4	6.0	3.1	S4,Adult,Walk+,Light,No
2	15	N	16	1.6	1.0	5.0	3.1	S4,Adult,Walk+,Light,No	2	34	N	34	1.8	1.4	5.9	3.1	S4,Adult,Walk+,Light,No
2	15	N	15	1.6	0.9	5.1	3.1	S4,Adult,Walk+,Light,No	2	37	N	38	1.5	1.4	6.9	3.1	S4,Adult,Walk+,Light,No
2	15	N	16	1.3	0.9	5.5	3.1	S4,Adult,Walk+,Light,No	2	37	N	37	1.5	1.4	6.7	3.1	S4,Adult,Walk+,Light,No
2	19	N	18	2.1	1.6	3.9	3.1	S4,Adult,Walk+,Light,No	2	37	N	37	1.3	1.2	7.6	3.1	S4,Adult,Walk+,Light,No
2	19	N	19	1.6	1.1	5.2	3.1	S4,Adult,Walk+,Light,No	2	32	Y	35	3.3	1.4	5.7	3.1	S4,Adult,Walk+,Light,No
2	18	N	19	1.8	1.2	4.8	3.1	S4,Adult,Walk+,Light,No	3	9	N	9	2.3	1.6	1.5	3.1	S4,Adult,Walk+,Light,No
2	22	N	22	2.1	1.2	5.1	3.1	S4,Adult,Walk+,Light,No	3	9	N	9	2.3	1.6	1.2	3.1	S4,Adult,Walk+,Light,No

OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)	OEM	Speed Reduction (mph)	Impact?	Veh Speed @ 4 s TTC (mph)	TTC @ Warn (s)	TTC @ AEB (s)	AEB Level (m/s^2)	Ped Speed (mph)	Simulation String (Scenario, Size, Speed, Light, Obstruction)
3	9	N	9	2.5	1.9	0.9	3.1	S4,Adult,Walk+,Light,No	3	12	N	12	2.1	1.4	3.2	3.1	S4,Adult,Walk+,Light,No
3	12	N	13	2.1	1.4	2.9	3.1	S4,Adult,Walk+,Light,No	3	16	N	16	1.8	1.3	3.9	3.1	S4,Adult,Walk+,Light,No
3	12	N	12	2.2	1.4	3.3	3.1	S4,Adult,Walk+,Light,No	3	16	N	16	1.9	1.3	3.9	3.2	S4,Adult,Walk+,Light,No
3	12	N	13	2.1	1.4	2.8	3.1	S4,Adult,Walk+,Light,No	3	16	N	16	1.8	1.3	3.8	3.2	S4,Adult,Walk+,Light,No
3	15	N	16	2.0	1.4	3.4	3.1	S4,Adult,Walk+,Light,No	3	19	N	19	1.8	1.4	3.2	3.2	S4,Adult,Walk+,Light,No
3	15	N	15	2.0	1.3	2.8	3.1	S4,Adult,Walk+,Light,No	3	19	N	18	1.6	1.3	3.3	3.2	S4,Adult,Walk+,Light,No
3	16	N	16	2.0	1.4	3.8	3.1	S4,Adult,Walk+,Light,No	3	22	N	22	1.7	1.4	4.8	3.2	S4,Adult,Walk+,Light,No
3	18	N	19	1.9	1.3	4.2	3.1	S4,Adult,Walk+,Light,No	3	22	N	22	1.7	1.3	5.1	3.1	S4,Adult,Walk+,Light,No
3	18	N	19	1.8	1.4	4.5	3.1	S4,Adult,Walk+,Light,No	3	25	N	25	1.7	1.3	5.6	3.1	S4,Adult,Walk+,Light,No
3	19	N	19	2.5	1.4	3.6	3.1	S4,Adult,Walk+,Light,No	3	25	N	25	1.7	1.4	5.4	3.0	S4,Adult,Walk+,Light,No
3	22	N	22	1.9	1.4	4.9	3.1	S4,Adult,Walk+,Light,No	3	25	N	25	1.4	1.3	6.0	3.1	S4,Adult,Walk+,Light,No
3	22	N	22	1.9	1.4	5.2	3.1	S4,Adult,Walk+,Light,No	3	27	N	28	1.5	1.3	6.1	3.1	S4,Adult,Walk+,Light,No
3	22	N	22	1.8	1.4	5.3	3.1	S4,Adult,Walk+,Light,No	3	29	Y	38	1.4	1.3	6.0	3.1	S4,Adult,Walk+,Light,No
3	25	N	25	1.8	1.3	5.8	3.1	S4,Adult,Walk+,Light,No	3	2	Y	18	1.7	1.4	1.1	3.1	S4,Adult,Walk+,Light,No
3	25	N	25	1.5	1.4	5.9	3.1	S4,Adult,Walk+,Light,No	3	12	Y	29	1.2	2.0	2.7	3.1	S4,Adult,Walk+,Light,No
3	25	N	25	1.8	1.3	5.7	3.1	S4,Adult,Walk+,Light,No	3	3	Y	32	0.8	2.6	0.9	3.1	S4,Adult,Walk+,Light,No
3	28	N	29	1.8	1.4	5.8	3.1	S4,Adult,Walk+,Light,No	3	2	Y	19	1.7	0.5	4.3	3.1	S4,Adult,Walk+,Light,No
3	28	N	28	1.8	1.4	5.8	3.1	S4,Adult,Walk+,Light,No	3	9	Y	22	1.0	0.5	4.6	3.1	S4,Adult,Walk+,Light,No
3	28	N	28	1.8	1.4	6.0	3.1	S4,Adult,Walk+,Light,No	3	0	Y	28	1.8	0.0	0.0	3.1	S4,Adult,Walk+,Light,No
3	31	N	31	1.7	1.4	6.5	3.1	S4,Adult,Walk+,Light,No									
3	31	N	31	1.5	1.4	6.6	3.1	S4,Adult,Walk+,Light,No									
3	31	N	31	1.7	1.4	6.4	3.1	S4,Adult,Walk+,Light,No									
3	35	N	35	1.5	1.4	6.5	3.1	S4,Adult,Walk+,Light,No									
3	34	N	35	1.7	1.4	6.4	3.1	S4,Adult,Walk+,Light,No									
3	34	N	34	1.7	1.4	6.1	3.1	S4,Adult,Walk+,Light,No									
3	37	N	37	1.6	1.4	6.6	3.1	S4,Adult,Walk+,Light,No									
3	10	N	9	2.3	1.7	2.1	3.1	S4,Adult,Walk+,Light,No									
3	10	N	10	2.3	1.6	2.3	3.2	S4,Adult,Walk+,Light,No									
3	10	N	10	2.3	1.6	1.5	3.1	S4,Adult,Walk+,Light,No									
3	13	N	13	2.0	1.4	3.5	3.0	S4,Adult,Walk+,Light,No									
3	12	N	12	2.2	1.4	3.3	3.1	S4,Adult,Walk+,Light,No									
3	12	N	12	2.1	1.4	3.1	3.2	S4,Adult,Walk+,Light,No									
3	15	N	15	1.9	1.3	2.9	3.2	S4,Adult,Walk+,Light,No									
3	16	N	15	1.9	1.3	2.6	3.1	S4,Adult,Walk+,Light,No									
3	15	N	15	2.1	1.3	4.0	3.2	S4,Adult,Walk+,Light,No									
3	18	N	18	1.9	1.3	4.3	3.1	S4,Adult,Walk+,Light,No									
3	19	N	18	1.7	1.4	3.1	3.1	S4,Adult,Walk+,Light,No									
3	22	N	21	1.8	1.4	3.6	3.1	S4,Adult,Walk+,Light,No									
3	21	N	22	1.7	1.3	3.8	3.1	S4,Adult,Walk+,Light,No									
3	21	N	21	1.7	1.3	3.9	3.3	S4,Adult,Walk+,Light,No									
3	25	N	25	1.6	1.3	6.0	3.3	S4,Adult,Walk+,Light,No									
3	25	N	24	1.6	1.3	5.5	3.1	S4,Adult,Walk+,Light,No									
3	26	N	25	1.5	1.3	5.9	3.1	S4,Adult,Walk+,Light,No									
3	28	N	28	1.6	1.5	6.1	3.1	S4,Adult,Walk+,Light,No									
3	28	N	28	1.8	1.6	5.3	3.0	S4,Adult,Walk+,Light,No									
3	9	N	9	2.3	1.6	1.7	3.0	S4,Adult,Walk+,Light,No									
3	9	N	9	2.3	1.6	1.3	3.1	S4,Adult,Walk+,Light,No									
3	9	N	10	2.3	1.7	2.1	3.0	S4,Adult,Walk+,Light,No									
3	12	N	12	2.0	1.4	3.3	3.2	S4,Adult,Walk+,Light,No									
3	13	N	13	1.6	1.2	3.9	3.2	S4,Adult,Walk+,Light,No									

APPENDIX E: BASELINE CURVE FITTING

Table 52: Observed Statistics for Normal Distribution Function of Baseline Crash Data for an Adult Walking in S1 during the Night with no Obstruction

Variable		GES	FARS
Mean	μ	N/A*	9.10
Standard Deviation	σ	N/A*	2.43

*Only 1 FARS case was identified to meet this baseline criteria

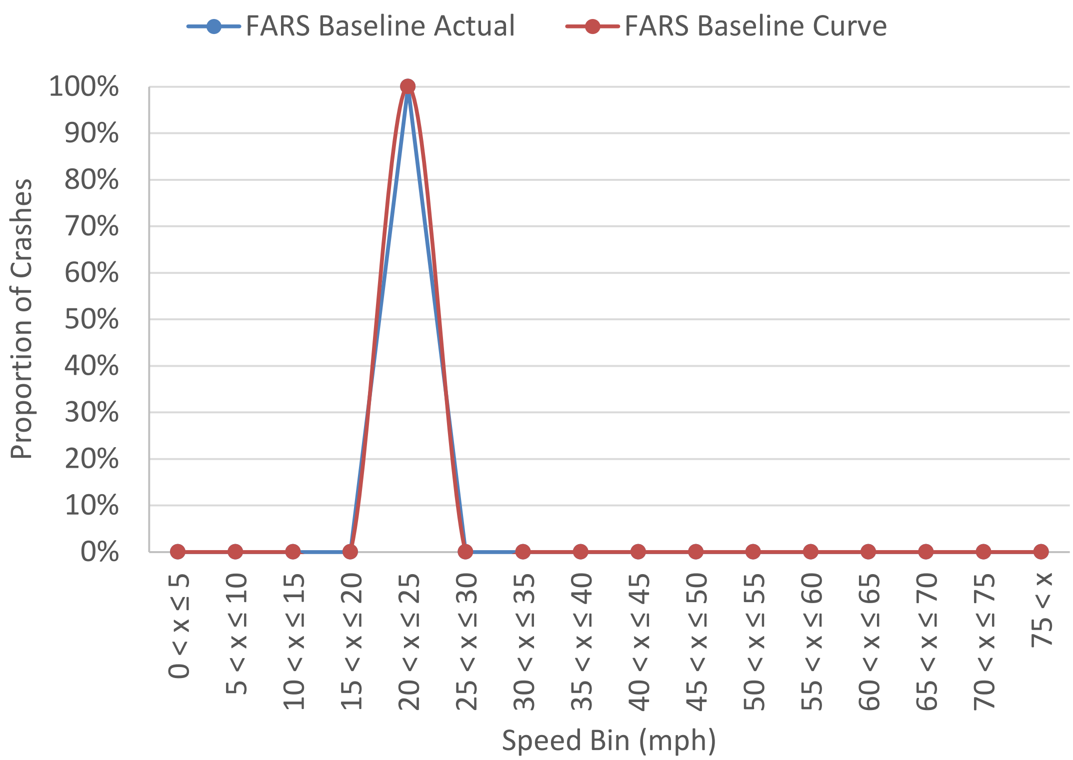

Figure 26: Plots of Normal Distribution Function Compared to Actual FARS Data for an Adult Running in S1 During the Day With No Obstruction

Table 53: Observed Statistics for Normal Distribution Function of Baseline Crash Data for a Child Walking in S1 During the Day With No Obstruction

Variable		GES	FARS
Mean	μ	1.11	7.74
Standard Deviation	σ	0.97	3.22

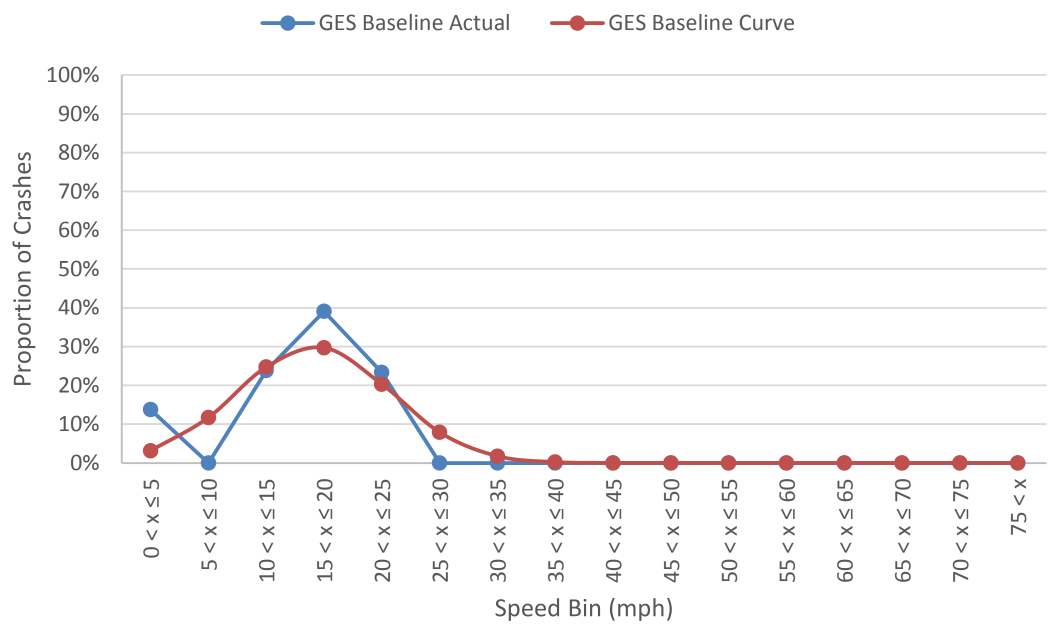

Figure 27: Plots of Normal Distribution Function Compared to Actual GES Data for a Child Walking in S1 During the Day With No Obstruction

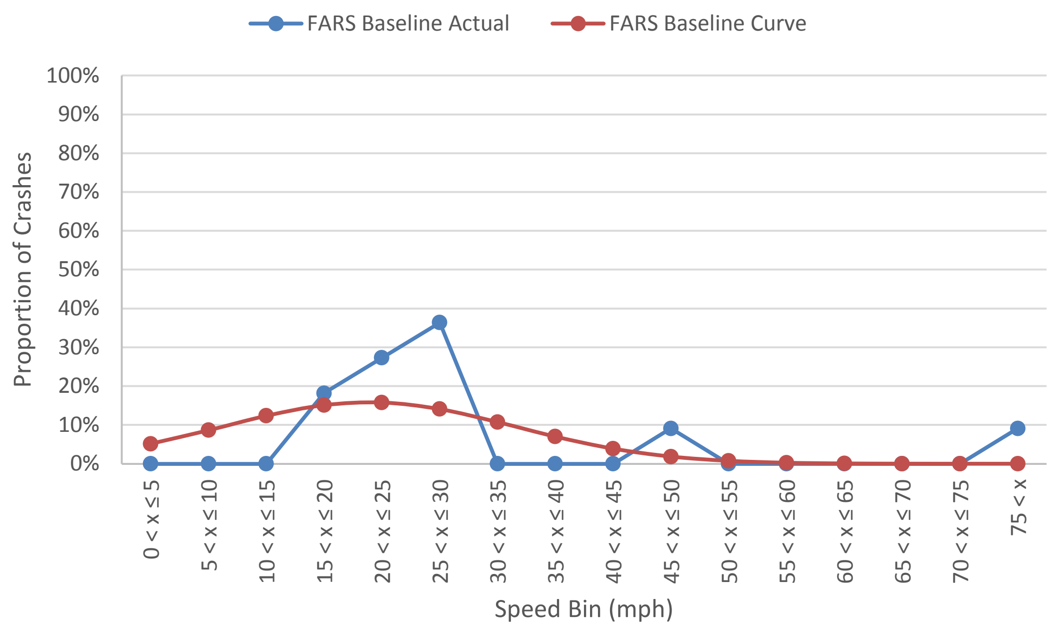

Figure 28: Plots of Normal Distribution Function Compared to Actual FARS Data for a Child Walking in S1 During the Day With No Obstruction

Table 54: Observed Statistics for Normal Distribution Function of Baseline Crash Data for a Child Walking in S1 During the Day With an Obstruction

Variable		GES	FARS
Mean	μ	1.13	4.78
Standard Deviation	σ	0.57	2.52

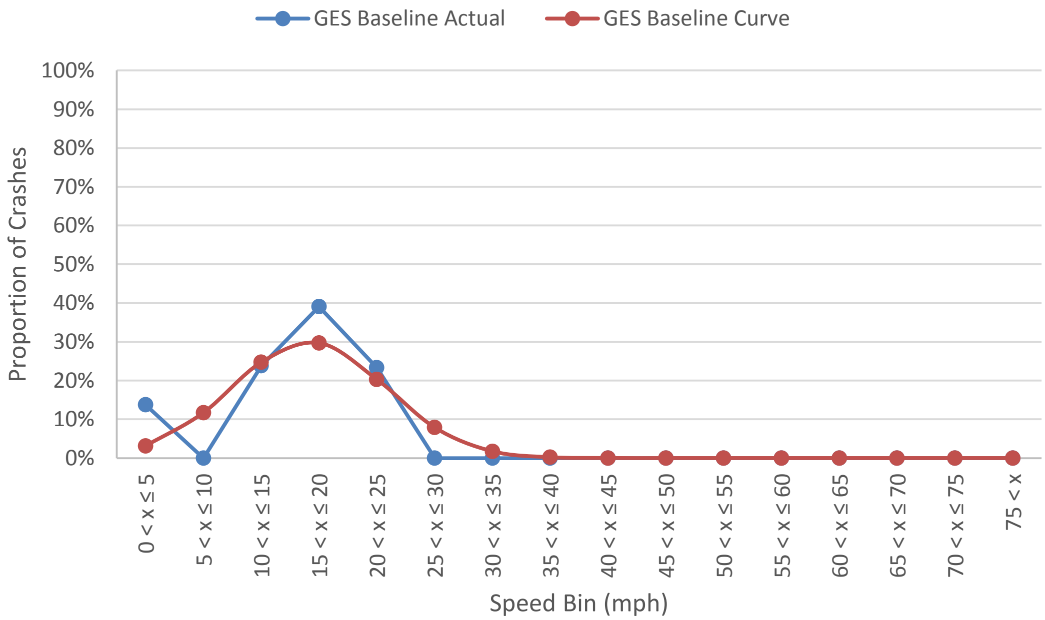

Figure 29: Plots of Normal Distribution Function Compared to Actual GES Data for a Child Walking in S1 During the Day With an Obstruction

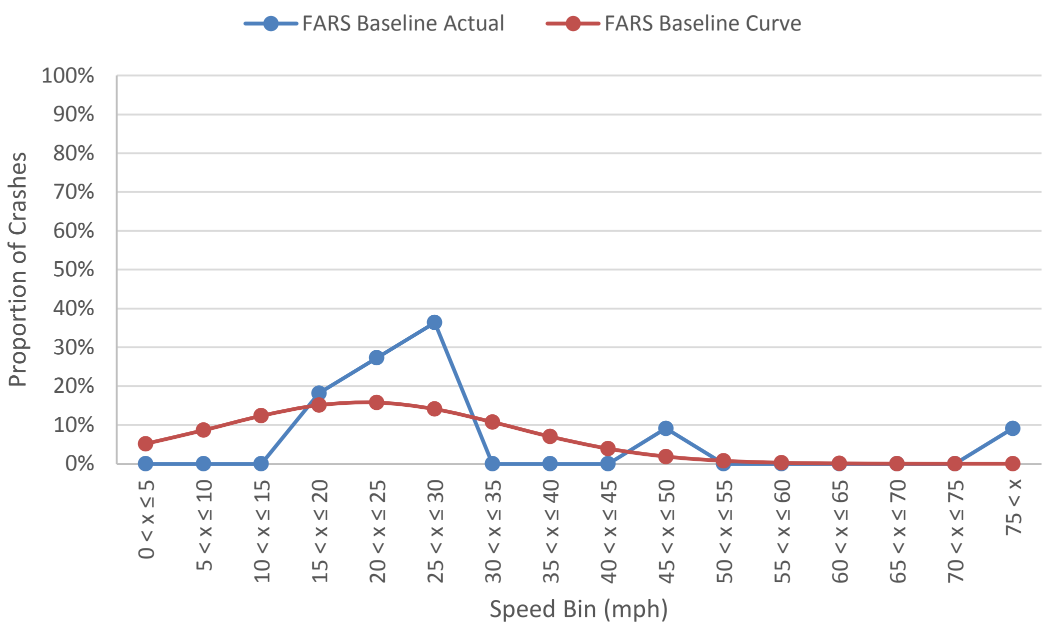

Figure 30: Plots of Normal Distribution Function Compared to Actual FARS Data for a Child Walking in S1 During the Day With an Obstruction

Table 55: Observed Statistics for Normal Distribution Function of Baseline Crash Data for an Adult Walking With Traffic in S4 During the Day With No Obstruction

Variable		GES	FARS
Mean	μ	2.64	8.86
Standard Deviation	σ	0.93	2.69

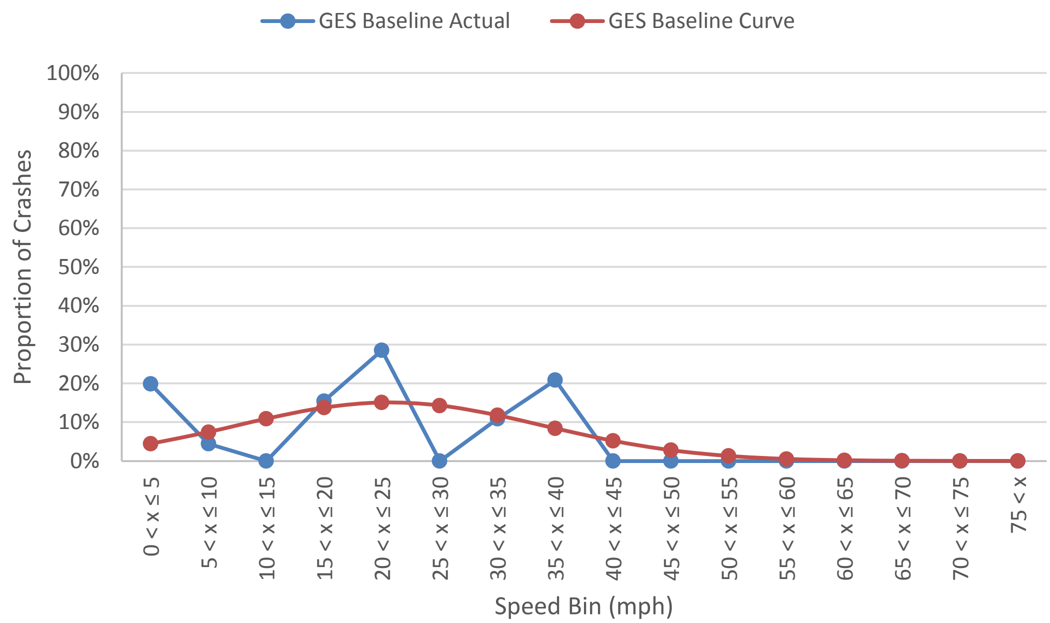

Figure 31: Plots of Normal Distribution Function Compared to Actual GES Data for an Adult Walking With Traffic in S4 During the Day With No Obstruction

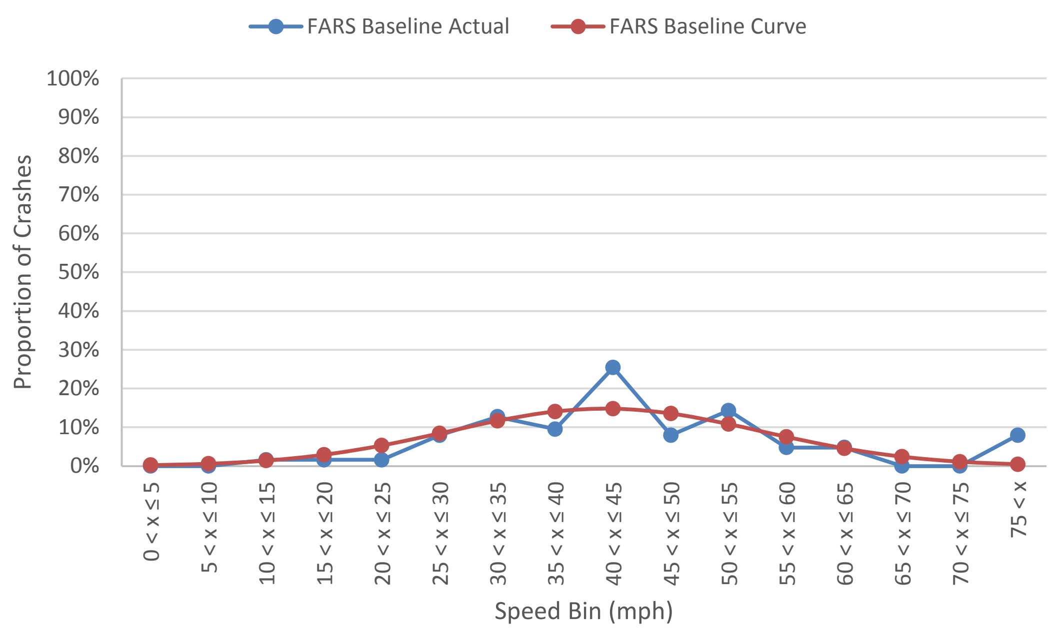

Figure 32: Plots of Normal Distribution Function Compared to Actual FARS Data for an Adult Walking With Traffic in S4 During the Day With No Obstruction

APPENDIX F: TREATMENT CURVE FITTING

Table 56: Observed Statistics and Results for Log Normal Distribution Function of Treatment Crash Data for an Adult Walking in S1 During the Day With No Obstruction for OEM 1

Variable		OEM 1					
		GES Cases			FARS Cases		
		AEB	First	Best	AEB	First	Best
Mean	μ	0.86	0.85	0.84	0.73	0.73	0.73
Standard Deviation	σ	0.33	0.33	0.33	0.47	0.47	0.47
Probability of Crash		24%	24%	23%	48%	48%	48%

Speed Bin (mph)		GES Cases						FARS Cases					
		AEB Only		First Brake		Best Brake		AEB Only		First Brake		Best Brake	
		Actual	Curve	Actual	Actual	Curve	Actual	Actual	Curve	Actual	Curve	Actual	Curve
1	0 < x ≤ 5	36.3%	3.7%	38.3%	4.3%	40.1%	5.0%	23.4%	25.4%	23.5%	25.4%	23.5%	25.4%
2	5 < x ≤ 10	55.3%	53.8%	53.4%	54.4%	51.4%	54.0%	41.9%	42.0%	41.9%	42.0%	41.9%	42.0%
3	10 < x ≤ 15	5.0%	31.3%	4.9%	30.3%	5.1%	29.6%	13.8%	20.9%	13.8%	20.9%	13.8%	20.9%
4	15 < x ≤ 20	3.4%	8.3%	3.4%	7.9%	3.5%	7.9%	10.1%	8.1%	10.1%	8.1%	10.1%	8.1%
5	20 < x ≤ 25	0.0%	1.7%	0.0%	1.6%	0.0%	1.7%	0.8%	3.0%	0.8%	3.0%	0.8%	3.0%
6	25 < x ≤ 30	0.0%	0.3%	0.0%	0.3%	0.0%	0.4%	0.8%	1.2%	0.8%	1.2%	0.8%	1.2%
7	30 < x ≤ 35	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%	9.0%	0.5%	9.0%	0.5%	9.0%	0.5%
8	35 < x ≤ 40	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.2%	0.0%	0.2%
9	40 < x ≤ 45	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%
10	45 < x ≤ 50	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
11	50 < x ≤ 55	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
12	55 < x ≤ 60	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
13	60 < x ≤ 65	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
14	65 < x ≤ 70	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
15	70 < x ≤ 75	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
16	75 < x	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 57: Observed Statistics and Results for Log Normal Distribution Function of Treatment Crash Data for an Adult Walking in S1 During the Day With No Obstruction for OEM 2

Variable		OEM 2					
		GES Cases			FARS Cases		
		AEB	First	Best	AEB	First	Best
Mean	μ	0.79	0.79	0.80	0.87	0.87	0.87
Standard Deviation	σ	0.39	0.39	0.39	0.54	0.54	0.54
Probability of Crash		25%	25%	25%	51%	51%	51%

Speed Bin (mph)		GES Cases						FARS Cases					
		AEB Only		First Brake		Best Brake		AEB Only		First Brake		Best Brake	
		Actual	Curve	Actual	Actual	Curve	Actual	Actual	Curve	Actual	Curve	Actual	Curve
1	0 < x ≤ 5	45.8%	13.0%	45.8%	13.1%	45.4%	12.9%	20.9%	19.8%	20.9%	19.8%	20.9%	19.8%
2	5 < x ≤ 10	35.2%	49.2%	35.2%	49.2%	35.4%	49.0%	35.4%	35.0%	35.4%	35.0%	35.3%	35.0%
3	10 < x ≤ 15	11.3%	25.1%	11.3%	25.1%	11.4%	25.2%	17.1%	22.6%	17.1%	22.6%	17.1%	22.6%
4	15 < x ≤ 20	7.3%	8.1%	7.4%	8.2%	7.4%	8.3%	14.3%	11.8%	14.3%	11.8%	14.3%	11.8%
5	20 < x ≤ 25	0.3%	2.3%	0.3%	2.4%	0.3%	2.4%	2.9%	5.8%	2.9%	5.8%	2.9%	5.8%
6	25 < x ≤ 30	0.0%	0.7%	0.0%	0.7%	0.0%	0.7%	0.9%	2.9%	0.9%	2.9%	0.9%	2.9%
7	30 < x ≤ 35	0.0%	0.2%	0.0%	0.2%	0.0%	0.2%	7.0%	1.5%	7.0%	1.5%	7.0%	1.5%
8	35 < x ≤ 40	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%	1.6%	0.8%	1.6%	0.8%	1.6%	0.8%
9	40 < x ≤ 45	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.0%	0.4%	0.0%	0.4%
10	45 < x ≤ 50	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.2%	0.0%	0.2%
11	50 < x ≤ 55	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%
12	55 < x ≤ 60	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%
13	60 < x ≤ 65	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
14	65 < x ≤ 70	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
15	70 < x ≤ 75	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
16	75 < x	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 58: Observed Statistics and Results for Log Normal Distribution Function of Treatment Crash Data for an Adult Walking in S1 During the Day With No Obstruction for OEM 3

Variable		OEM 3					
		GES Cases			FARS Cases		
		AEB	First	Best	AEB	First	Best
Mean	μ	1.03	1.03	1.02	1.18	1.18	1.18
Standard Deviation	σ	0.43	0.43	0.42	0.53	0.53	0.53
Probability of Crash		60%	60%	60%	93%	93%	93%

Speed Bin (mph)		GES Cases						FARS Cases					
		AEB Only		First Brake		Best Brake		AEB Only		First Brake		Best Brake	
		Actual	Curve	Actual	Actual	Curve	Actual	Actual	Curve	Actual	Curve	Actual	Curve
1	0 < x ≤ 5	17.7%	5.0%	17.8%	5.0%	17.8%	5.1%	4.3%	6.2%	4.3%	6.2%	4.3%	6.4%
2	5 < x ≤ 10	34.0%	34.2%	33.9%	34.2%	33.9%	34.9%	22.1%	24.5%	22.2%	24.5%	22.2%	24.8%
3	10 < x ≤ 15	21.3%	30.8%	21.2%	30.8%	23.2%	31.0%	22.7%	24.7%	22.7%	24.7%	25.0%	24.8%
4	15 < x ≤ 20	22.4%	16.5%	22.5%	16.5%	20.6%	16.2%	33.9%	17.5%	33.9%	17.5%	31.8%	17.4%
5	20 < x ≤ 25	4.2%	7.4%	4.2%	7.4%	4.2%	7.2%	8.2%	10.9%	8.1%	10.9%	8.0%	10.8%
6	25 < x ≤ 30	0.4%	3.2%	0.4%	3.2%	0.4%	3.0%	3.3%	6.5%	3.3%	6.5%	3.2%	6.4%
7	30 < x ≤ 35	0.0%	1.3%	0.0%	1.3%	0.0%	1.2%	0.7%	3.8%	0.7%	3.8%	0.7%	3.7%
8	35 < x ≤ 40	0.0%	0.6%	0.0%	0.6%	0.0%	0.5%	2.5%	2.3%	2.5%	2.3%	2.5%	2.2%
9	40 < x ≤ 45	0.0%	0.2%	0.0%	0.2%	0.0%	0.2%	2.3%	1.4%	2.3%	1.4%	2.3%	1.3%
10	45 < x ≤ 50	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%	0.0%	0.8%	0.0%	0.8%	0.0%	0.8%
11	50 < x ≤ 55	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.0%	0.5%	0.0%	0.5%
12	55 < x ≤ 60	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.3%	0.0%	0.3%
13	60 < x ≤ 65	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.2%	0.0%	0.2%
14	65 < x ≤ 70	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%
15	70 < x ≤ 75	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
16	75 < x	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 59: Observed Statistics and Results for Log Normal Distribution Function of Treatment Crash Data for an Adult Running in S1 During the Day With No Obstruction for OEM 1

Variable		OEM 1					
		GES Cases			FARS Cases		
		AEB	First	Best	AEB	First	Best
Mean	μ				0.80	0.80	0.80
Standard Deviation	σ				0.28	0.28	0.28
Probability of Crash					90%	90%	90%

Speed Bin (mph)		GES Cases						FARS Cases					
		AEB Only		First Brake		Best Brake		AEB Only		First Brake		Best Brake	
		Actual	Curve	Actual	Actual	Curve	Actual	Actual	Curve	Actual	Curve	Actual	Curve
1	0 < x ≤ 5							29.8%	2.1%	30.1%	2.1%	30.1%	2.1%
2	5 < x ≤ 10							57.6%	66.8%	57.4%	66.8%	57.4%	66.8%
3	10 < x ≤ 15							12.6%	27.2%	12.5%	27.1%	12.5%	27.1%
4	15 < x ≤ 20							0.0%	3.9%	0.0%	3.9%	0.0%	3.9%
5	20 < x ≤ 25							0.0%	0.4%	0.0%	0.4%	0.0%	0.4%
6	25 < x ≤ 30							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
7	30 < x ≤ 35							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
8	35 < x ≤ 40							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
9	40 < x ≤ 45							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
10	45 < x ≤ 50							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
11	50 < x ≤ 55							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
12	55 < x ≤ 60							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
13	60 < x ≤ 65							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
14	65 < x ≤ 70							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
15	70 < x ≤ 75							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
16	75 < x							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 60: Observed Statistics and Results for Log Normal Distribution Function of Treatment Crash Data for an Adult Running in S1 During the Day With No Obstruction for OEM 2

Variable		OEM 2					
		GES Cases			FARS Cases		
		AEB	First	Best	AEB	First	Best
Mean	μ				0.79	0.79	0.79
Standard Deviation	σ				0.25	0.25	0.25
Probability of Crash					32%	32%	32%

Speed Bin (mph)		GES Cases						FARS Cases					
		AEB Only		First Brake		Best Brake		AEB Only		First Brake		Best Brake	
		Actual	Curve	Actual	Actual	Curve	Actual	Actual	Curve	Actual	Curve	Actual	Curve
1	0 < x ≤ 5							44.7%	1.3%	44.5%	1.3%	45.0%	1.3%
2	5 < x ≤ 10							55.3%	72.6%	55.5%	72.6%	55.0%	72.6%
3	10 < x ≤ 15							0.0%	25.3%	0.0%	25.3%	0.0%	25.3%
4	15 < x ≤ 20							0.0%	2.6%	0.0%	2.6%	0.0%	2.6%
5	20 < x ≤ 25							0.0%	0.2%	0.0%	0.2%	0.0%	0.2%
6	25 < x ≤ 30							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
7	30 < x ≤ 35							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
8	35 < x ≤ 40							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
9	40 < x ≤ 45							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
10	45 < x ≤ 50							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
11	50 < x ≤ 55							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
12	55 < x ≤ 60							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
13	60 < x ≤ 65							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
14	65 < x ≤ 70							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
15	70 < x ≤ 75							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
16	75 < x							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 61: Observed Statistics and Results for Log Normal Distribution Function of Treatment Crash Data for an Adult Running in S1 During the Day With No Obstruction for OEM 3

Variable		OEM 3					
		GES Cases			FARS Cases		
		AEB	First	Best	AEB	First	Best
Mean	μ				1.02	1.02	1.02
Standard Deviation	σ				0.41	0.41	0.41
Probability of Crash					100%	100%	100%

Speed Bin (mph)		GES Cases						FARS Cases					
		AEB Only		First Brake		Best Brake		AEB Only		First Brake		Best Brake	
		Actual	Curve	Actual	Actual	Curve	Actual	Actual	Curve	Actual	Curve	Actual	Curve
1	0 < x ≤ 5							31.0%	4.4%	31.5%	4.5%	31.2%	4.6%
2	5 < x ≤ 10							20.4%	35.1%	20.5%	35.4%	21.1%	35.6%
3	10 < x ≤ 15							48.7%	31.7%	48.0%	31.7%	47.7%	31.7%
4	15 < x ≤ 20							0.0%	16.4%	0.0%	16.3%	0.0%	16.2%
5	20 < x ≤ 25							0.0%	7.0%	0.0%	6.9%	0.0%	6.9%
6	25 < x ≤ 30							0.0%	2.8%	0.0%	2.8%	0.0%	2.7%
7	30 < x ≤ 35							0.0%	1.1%	0.0%	1.1%	0.0%	1.1%
8	35 < x ≤ 40							0.0%	0.5%	0.0%	0.4%	0.0%	0.4%
9	40 < x ≤ 45							0.0%	0.2%	0.0%	0.2%	0.0%	0.2%
10	45 < x ≤ 50							0.0%	0.1%	0.0%	0.1%	0.0%	0.1%
11	50 < x ≤ 55							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
12	55 < x ≤ 60							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
13	60 < x ≤ 65							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
14	65 < x ≤ 70							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
15	70 < x ≤ 75							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
16	75 < x							0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 62: Observed Statistics and Results for Log Normal Distribution Function of Treatment Crash Data for a Child Walking in S1 During the Day With No Obstruction for OEM 1

Variable		OEM 1					
		GES Cases			FARS Cases		
		AEB	First	Best	AEB	First	Best
Mean	μ	0.59	0.58	0.59	0.99	0.99	0.99
Standard Deviation	σ	0.08	0.09	0.08	0.50	0.50	0.50
Probability of Crash		10%	11%	10%	63%	64%	63%

Speed Bin (mph)		GES Cases						FARS Cases					
		AEB Only		First Brake		Best Brake		AEB Only		First Brake		Best Brake	
		Actual	Curve	Actual	Actual	Curve	Actual	Actual	Curve	Actual	Curve	Actual	Curve
1	0 < x ≤ 5	7.1%	0.0%	9.9%	0.0%	7.1%	0.0%	3.1%	11.2%	3.3%	11.3%	3.1%	11.2%
2	5 < x ≤ 10	92.9%	100.4%	89.6%	100.0%	92.9%	100.4%	32.9%	33.6%	32.7%	33.6%	32.9%	33.6%
3	10 < x ≤ 15	0.0%	0.0%	0.6%	0.0%	0.0%	0.0%	29.9%	26.0%	29.9%	26.0%	29.8%	26.0%
4	15 < x ≤ 20	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	25.6%	14.5%	25.5%	14.5%	25.6%	14.5%
5	20 < x ≤ 25	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.3%	0.1%	7.3%	0.0%	7.3%
6	25 < x ≤ 30	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.6%	0.0%	3.6%	0.0%	3.6%
7	30 < x ≤ 35	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.8%	0.0%	1.8%	0.0%	1.8%
8	35 < x ≤ 40	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.5%	0.9%	8.5%	0.9%	8.5%	0.9%
9	40 < x ≤ 45	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.0%	0.5%	0.0%	0.5%
10	45 < x ≤ 50	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.2%	0.0%	0.2%
11	50 < x ≤ 55	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%
12	55 < x ≤ 60	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%
13	60 < x ≤ 65	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
14	65 < x ≤ 70	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
15	70 < x ≤ 75	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
16	75 < x	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 63: Observed Statistics and Results for Log Normal Distribution Function of Treatment Crash Data for a Child Walking in S1 During the Day With No Obstruction for OEM 2

Variable		OEM 2					
		GES Cases			FARS Cases		
		AEB	First	Best	AEB	First	Best
Mean	μ	0.08	0.08	0.08	1.09	1.09	1.09
Standard Deviation	σ	0.04	0.04	0.04	0.56	0.56	0.56
Probability of Crash		30%	30%	29%	64%	64%	64%

	Speed Bin (mph)	GES Cases						FARS Cases					
		AEB Only		First Brake		Best Brake		AEB Only		First Brake		Best Brake	
		Actual	Curve	Actual	Actual	Curve	Actual	Actual	Curve	Actual	Curve	Actual	Curve
1	0 < x ≤ 5	76.2%	100.0%	76.2%	100.2%	75.4%	100.4%	9.7%	11.0%	9.7%	11.0%	8.9%	10.6%
2	5 < x ≤ 10	16.6%	0.0%	16.6%	0.0%	17.2%	0.0%	20.3%	27.8%	20.3%	27.8%	20.5%	27.6%
3	10 < x ≤ 15	7.2%	0.0%	7.3%	0.0%	7.5%	0.0%	36.3%	23.6%	36.3%	23.6%	36.6%	23.7%
4	15 < x ≤ 20	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	23.9%	15.4%	23.9%	15.4%	24.1%	15.5%
5	20 < x ≤ 25	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.4%	9.2%	1.4%	9.2%	1.4%	9.3%
6	25 < x ≤ 30	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.4%	0.0%	5.4%	0.0%	5.5%
7	30 < x ≤ 35	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.1%	0.0%	3.1%	0.0%	3.2%
8	35 < x ≤ 40	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.4%	1.9%	8.4%	1.9%	8.5%	1.9%
9	40 < x ≤ 45	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.1%	0.0%	1.1%	0.0%	1.1%
10	45 < x ≤ 50	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	0.0%	0.7%	0.0%	0.7%
11	50 < x ≤ 55	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.0%	0.4%	0.0%	0.4%
12	55 < x ≤ 60	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.3%	0.0%	0.3%
13	60 < x ≤ 65	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.2%	0.0%	0.2%
14	65 < x ≤ 70	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%
15	70 < x ≤ 75	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%
16	75 < x	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 64: Observed Statistics and Results for Log Normal Distribution Function of Treatment Crash Data for a Child Walking in S1 During the Day With No Obstruction for OEM 3

Variable		OEM 3					
		GES Cases			FARS Cases		
		AEB	First	Best	AEB	First	Best
Mean	μ	0.97	0.97	0.97	1.26	1.26	1.26
Standard Deviation	σ	0.33	0.33	0.33	0.54	0.54	0.54
Probability of Crash		36%	36%	36%	88%	88%	88%

	Speed Bin (mph)	GES Cases						FARS Cases					
		AEB Only		First Brake		Best Brake		AEB Only		First Brake		Best Brake	
		Actual	Curve	Actual	Actual	Curve	Actual	Actual	Curve	Actual	Curve	Actual	Curve
1	0 < x ≤ 5	12.1%	1.6%	12.1%	1.6%	12.1%	1.6%	3.8%	5.0%	3.8%	5.0%	3.8%	5.0%
2	5 < x ≤ 10	38.5%	42.5%	38.4%	42.5%	38.5%	42.6%	12.8%	21.4%	12.8%	21.4%	12.8%	21.5%
3	10 < x ≤ 15	38.2%	37.3%	38.2%	37.3%	38.2%	37.3%	31.2%	23.5%	31.2%	23.5%	31.2%	23.5%
4	15 < x ≤ 20	11.3%	13.6%	11.3%	13.7%	11.2%	13.6%	27.3%	17.9%	27.4%	17.9%	27.4%	17.9%
5	20 < x ≤ 25	0.0%	3.7%	0.0%	3.7%	0.0%	3.7%	16.8%	11.9%	16.7%	11.9%	16.7%	11.9%
6	25 < x ≤ 30	0.0%	0.9%	0.0%	0.9%	0.0%	0.9%	1.9%	7.5%	1.9%	7.5%	1.9%	7.5%
7	30 < x ≤ 35	0.0%	0.2%	0.0%	0.2%	0.0%	0.2%	0.0%	4.7%	0.0%	4.7%	0.0%	4.7%
8	35 < x ≤ 40	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%	2.3%	2.9%	2.3%	2.9%	2.3%	2.9%
9	40 < x ≤ 45	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.8%	1.8%	3.8%	1.8%	3.8%	1.8%
10	45 < x ≤ 50	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.1%	0.0%	1.1%	0.0%	1.1%
11	50 < x ≤ 55	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	0.0%	0.7%	0.0%	0.7%
12	55 < x ≤ 60	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.0%	0.5%	0.0%	0.5%
13	60 < x ≤ 65	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.3%	0.0%	0.3%
14	65 < x ≤ 70	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.2%	0.0%	0.2%
15	70 < x ≤ 75	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%
16	75 < x	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%

Table 65: Observed Statistics and Results for Log Normal Distribution Function of Treatment Crash Data for a Child Walking in S1 During the Day With an Obstruction for OEM 1

Variable		OEM 1					
		GES Cases			FARS Cases		
		AEB	First	Best	AEB	First	Best
Mean	μ	0.85	0.81	0.85	1.01	1.07	1.07
Standard Deviation	σ	0.34	0.33	0.35	0.61	0.65	0.65
Probability of Crash		80%	80%	80%	100%	100%	100%

Speed Bin (mph)		GES Cases						FARS Cases					
		AEB Only		First Brake		Best Brake		AEB Only		First Brake		Best Brake	
		Actual	Curve	Actual	Actual	Curve	Actual	Actual	Curve	Actual	Curve	Actual	Curve
1	0 < x ≤ 5	39.6%	5.6%	40.1%	6.0%	39.9%	5.7%	10.1%	16.7%	10.1%	15.6%	10.2%	15.7%
2	5 < x ≤ 10	41.7%	52.2%	40.8%	56.2%	41.2%	52.1%	17.4%	28.8%	17.4%	26.0%	17.3%	26.0%
3	10 < x ≤ 15	18.7%	29.7%	19.1%	27.6%	18.9%	29.6%	54.3%	21.7%	54.3%	20.5%	54.3%	20.5%
4	15 < x ≤ 20	0.0%	8.6%	0.0%	6.8%	0.0%	8.6%	0.0%	13.5%	0.0%	13.7%	0.0%	13.7%
5	20 < x ≤ 25	0.0%	2.0%	0.0%	1.4%	0.0%	2.1%	9.1%	8.0%	9.1%	8.7%	9.1%	8.7%
6	25 < x ≤ 30	0.0%	0.5%	0.0%	0.3%	0.0%	0.5%	0.0%	4.7%	0.0%	5.5%	0.0%	5.5%
7	30 < x ≤ 35	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%	0.0%	2.8%	0.0%	3.5%	0.0%	3.5%
8	35 < x ≤ 40	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.7%	0.0%	2.3%	0.0%	2.3%
9	40 < x ≤ 45	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.1%	1.1%	9.1%	1.5%	9.1%	1.5%
10	45 < x ≤ 50	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	0.0%	1.0%	0.0%	1.0%
11	50 < x ≤ 55	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.0%	0.7%	0.0%	0.7%
12	55 < x ≤ 60	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.5%	0.0%	0.5%
13	60 < x ≤ 65	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.3%	0.0%	0.3%
14	65 < x ≤ 70	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.2%	0.0%	0.2%
15	70 < x ≤ 75	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.2%	0.0%	0.2%
16	75 < x	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%

Table 66: Observed Statistics and Results for Log Normal Distribution Function of Treatment Crash Data for a Child Walking in S1 During the Day With an Obstruction for OEM 2

Variable		OEM 2					
		GES Cases			FARS Cases		
		AEB	First	Best	AEB	First	Best
Mean	μ	0.59	0.59	0.59	0.60	0.57	0.57
Standard Deviation	σ	0.17	0.17	0.17	0.46	0.44	0.44
Probability of Crash		78%	79%	78%	100%	100%	100%

Speed Bin (mph)		GES Cases						FARS Cases					
		AEB Only		First Brake		Best Brake		AEB Only		First Brake		Best Brake	
		Actual	Curve	Actual	Actual	Curve	Actual	Actual	Curve	Actual	Curve	Actual	Curve
1	0 < x ≤ 5	33.5%	0.5%	35.2%	0.6%	34.0%	0.5%	9.1%	37.1%	8.9%	38.8%	9.2%	38.9%
2	5 < x ≤ 10	66.5%	98.4%	64.8%	98.0%	66.0%	98.5%	72.7%	42.4%	72.9%	43.8%	72.6%	43.7%
3	10 < x ≤ 15	0.0%	0.8%	0.0%	1.0%	0.0%	0.8%	0.0%	16.1%	0.0%	14.8%	0.0%	14.8%
4	15 < x ≤ 20	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.1%	5.0%	9.1%	4.1%	9.1%	4.1%
5	20 < x ≤ 25	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.6%	0.0%	1.1%	0.0%	1.1%
6	25 < x ≤ 30	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.0%	0.3%	0.0%	0.3%
7	30 < x ≤ 35	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.1%	0.0%	0.1%
8	35 < x ≤ 40	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
9	40 < x ≤ 45	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.1%	0.0%	9.1%	0.0%	9.1%	0.0%
10	45 < x ≤ 50	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
11	50 < x ≤ 55	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
12	55 < x ≤ 60	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
13	60 < x ≤ 65	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
14	65 < x ≤ 70	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
15	70 < x ≤ 75	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
16	75 < x	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 67: Observed Statistics and Results for Log Normal Distribution Function of Treatment Crash Data for a Child Walking in S1 During the Day With an Obstruction for OEM 3

Variable		OEM 3					
		GES Cases			FARS Cases		
		AEB	First	Best	AEB	First	Best
Mean	µ	0.57	0.57	0.57	0.58	0.58	0.58
Standard Deviation	σ	0.12	0.12	0.12	0.39	0.39	0.39
Probability of Crash		61%	62%	61%	91%	91%	91%

Speed Bin (mph)		GES Cases						FARS Cases					
		AEB Only		First Brake		Best Brake		AEB Only		First Brake		Best Brake	
		Actual	Curve	Actual	Actual	Curve	Actual	Actual	Curve	Actual	Curve	Actual	Curve
1	0 < x ≤ 5	23.3%	0.0%	23.5%	0.0%	23.8%	0.0%	3.8%	33.9%	4.0%	34.0%	3.9%	33.9%
2	5 < x ≤ 10	76.7%	98.8%	76.5%	98.9%	76.2%	99.4%	76.2%	49.0%	76.0%	48.9%	76.1%	49.0%
3	10 < x ≤ 15	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	14.1%	0.0%	14.1%	0.0%	14.1%
4	15 < x ≤ 20	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	3.0%	10.0%	3.0%	10.0%	3.0%
5	20 < x ≤ 25	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.0%	0.6%	0.0%	0.6%
6	25 < x ≤ 30	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%
7	30 < x ≤ 35	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
8	35 < x ≤ 40	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	0.0%	10.0%	0.0%	10.0%	0.0%
9	40 < x ≤ 45	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
10	45 < x ≤ 50	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
11	50 < x ≤ 55	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
12	55 < x ≤ 60	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
13	60 < x ≤ 65	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
14	65 < x ≤ 70	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
15	70 < x ≤ 75	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
16	75 < x	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 68: Observed Statistics and Results for Log Normal Distribution Function of Treatment Crash Data for an Adult Stationary in S4 During the Day With No Obstruction for OEM 1

Variable		OEM 1					
		GES Cases			FARS Cases		
		AEB	First	Best	AEB	First	Best
Mean	µ	0.89	0.94	0.90	0.95	0.95	0.95
Standard Deviation	σ	0.70	0.73	0.71	0.68	0.67	0.68
Probability of Crash		51%	51%	50%	61%	62%	61%

Speed Bin (mph)		GES Cases						FARS Cases					
		AEB Only		First Brake		Best Brake		AEB Only		First Brake		Best Brake	
		Actual	Curve	Actual	Actual	Curve	Actual	Actual	Curve	Actual	Curve	Actual	Curve
1	0 < x ≤ 5	30.3%	25.3%	28.4%	23.8%	30.1%	25.0%	8.9%	22.0%	8.6%	21.7%	9.3%	22.1%
2	5 < x ≤ 10	16.9%	27.2%	16.7%	25.9%	16.9%	27.0%	20.8%	27.4%	19.9%	27.5%	20.9%	27.3%
3	10 < x ≤ 15	13.0%	18.1%	14.2%	17.9%	12.6%	18.1%	16.2%	19.2%	16.3%	19.3%	16.2%	19.1%
4	15 < x ≤ 20	1.1%	11.1%	2.6%	11.4%	0.9%	11.2%	10.6%	12.0%	11.3%	12.0%	10.0%	11.9%
5	20 < x ≤ 25	4.2%	6.8%	4.1%	7.2%	4.3%	6.8%	4.1%	7.4%	4.7%	7.4%	4.0%	7.3%
6	25 < x ≤ 30	4.3%	4.2%	4.2%	4.6%	4.3%	4.3%	3.2%	4.6%	3.3%	4.5%	3.1%	4.5%
7	30 < x ≤ 35	13.1%	2.6%	12.9%	3.0%	13.4%	2.7%	11.6%	2.9%	11.2%	2.9%	11.7%	2.9%
8	35 < x ≤ 40	9.1%	1.7%	9.0%	2.0%	9.3%	1.8%	5.3%	1.8%	5.5%	1.8%	5.3%	1.9%
9	40 < x ≤ 45	1.6%	1.1%	1.5%	1.4%	1.6%	1.2%	3.3%	1.2%	3.4%	1.2%	3.3%	1.2%
10	45 < x ≤ 50	0.0%	0.8%	0.0%	0.9%	0.0%	0.8%	4.1%	0.8%	4.1%	0.8%	4.1%	0.8%
11	50 < x ≤ 55	4.6%	0.5%	4.5%	0.7%	4.7%	0.5%	3.8%	0.6%	3.7%	0.5%	3.8%	0.6%
12	55 < x ≤ 60	1.9%	0.4%	1.9%	0.5%	1.9%	0.4%	3.0%	0.4%	3.0%	0.4%	3.1%	0.4%
13	60 < x ≤ 65	0.0%	0.3%	0.0%	0.3%	0.0%	0.3%	1.4%	0.3%	1.4%	0.3%	1.4%	0.3%
14	65 < x ≤ 70	0.0%	0.2%	0.0%	0.3%	0.0%	0.2%	1.1%	0.2%	1.1%	0.2%	1.1%	0.2%
15	70 < x ≤ 75	0.0%	0.1%	0.0%	0.2%	0.0%	0.1%	0.3%	0.1%	0.3%	0.1%	0.3%	0.1%
16	75 < x	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%	2.3%	0.1%	2.2%	0.1%	2.3%	0.1%

Table 69: Observed Statistics and Results for Log Normal Distribution Function of Treatment Crash Data for an Adult Stationary in S4 During the Day With No Obstruction for OEM 2

Variable		OEM 2					
		GES Cases			FARS Cases		
		AEB	First	Best	AEB	First	Best
Mean	μ	0.92	0.91	0.92	0.93	0.92	0.88
Standard Deviation	σ	0.69	0.70	0.70	0.73	0.73	0.70
Probability of Crash		36%	36%	35%	49%	50%	49%

Speed Bin (mph)		GES Cases						FARS Cases					
		AEB Only		First Brake		Best Brake		AEB Only		First Brake		Best Brake	
		Actual	Curve	Actual	Actual	Curve	Actual	Actual	Curve	Actual	Curve	Actual	Curve
1	0 < x ≤ 5	33.8%	23.7%	35.1%	24.5%	35.1%	24.0%	19.1%	24.4%	19.8%	24.9%	19.2%	25.8%
2	5 < x ≤ 10	9.8%	27.3%	10.6%	27.3%	9.8%	27.0%	18.8%	25.9%	19.8%	26.0%	19.7%	27.5%
3	10 < x ≤ 15	13.4%	18.6%	11.4%	18.4%	11.2%	18.4%	15.5%	17.7%	14.2%	17.6%	14.1%	18.1%
4	15 < x ≤ 20	2.6%	11.5%	2.6%	11.3%	2.7%	11.4%	10.4%	11.2%	10.3%	11.1%	10.5%	11.0%
5	20 < x ≤ 25	9.6%	7.0%	9.5%	6.9%	9.7%	7.0%	2.6%	7.1%	2.6%	7.0%	2.6%	6.6%
6	25 < x ≤ 30	20.6%	4.4%	20.6%	4.3%	21.1%	4.4%	5.5%	4.5%	5.5%	4.4%	5.5%	4.1%
7	30 < x ≤ 35	1.0%	2.8%	1.1%	2.7%	1.1%	2.8%	11.9%	3.0%	11.8%	2.9%	12.0%	2.6%
8	35 < x ≤ 40	0.0%	1.8%	0.0%	1.7%	0.0%	1.8%	0.0%	2.0%	0.0%	1.9%	0.0%	1.6%
9	40 < x ≤ 45	0.0%	1.2%	0.0%	1.1%	0.0%	1.2%	1.6%	1.3%	1.6%	1.3%	1.6%	1.1%
10	45 < x ≤ 50	0.0%	0.8%	0.0%	0.8%	0.0%	0.8%	4.9%	0.9%	4.8%	0.9%	4.9%	0.7%
11	50 < x ≤ 55	9.1%	0.5%	9.1%	0.5%	9.3%	0.6%	3.2%	0.7%	3.2%	0.6%	3.3%	0.5%
12	55 < x ≤ 60	0.0%	0.4%	0.0%	0.4%	0.0%	0.4%	3.2%	0.5%	3.2%	0.5%	3.3%	0.3%
13	60 < x ≤ 65	0.0%	0.3%	0.0%	0.3%	0.0%	0.3%	0.0%	0.3%	0.0%	0.3%	0.0%	0.2%
14	65 < x ≤ 70	0.0%	0.2%	0.0%	0.2%	0.0%	0.2%	1.6%	0.3%	1.6%	0.2%	1.6%	0.2%
15	70 < x ≤ 75	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%	0.0%	0.2%	0.0%	0.2%	0.0%	0.1%
16	75 < x	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%	1.7%	0.1%	1.6%	0.1%	1.7%	0.1%

Table 70: Observed Statistics and Results for Log Normal Distribution Function of Treatment Crash Data for an Adult Stationary in S4 During the Day With No Obstruction for OEM 3

Variable		OEM 3					
		GES Cases			FARS Cases		
		AEB	First	Best	AEB	First	Best
Mean	μ	0.80	0.80	0.80	1.01	1.01	1.01
Standard Deviation	σ	0.61	0.61	0.61	0.69	0.69	0.69
Probability of Crash		47%	47%	47%	66%	66%	66%

Speed Bin (mph)		GES Cases						FARS Cases					
		AEB Only		First Brake		Best Brake		AEB Only		First Brake		Best Brake	
		Actual	Curve	Actual	Actual	Curve	Actual	Actual	Curve	Actual	Curve	Actual	Curve
1	0 < x ≤ 5	8.9%	27.5%	9.2%	27.5%	8.7%	27.5%	2.9%	19.8%	3.0%	19.8%	2.9%	19.9%
2	5 < x ≤ 10	45.6%	32.2%	44.6%	32.2%	46.1%	32.1%	22.5%	26.0%	22.5%	26.0%	22.9%	26.0%
3	10 < x ≤ 15	9.8%	19.4%	10.4%	19.4%	9.3%	19.4%	19.5%	19.1%	19.3%	19.1%	19.2%	19.1%
4	15 < x ≤ 20	0.4%	10.3%	0.5%	10.3%	0.4%	10.4%	10.7%	12.4%	10.8%	12.4%	10.6%	12.4%
5	20 < x ≤ 25	1.1%	5.5%	1.1%	5.5%	1.1%	5.5%	5.3%	7.9%	5.3%	7.9%	5.2%	7.9%
6	25 < x ≤ 30	0.9%	2.9%	0.9%	2.9%	1.0%	2.9%	8.5%	5.1%	8.5%	5.1%	8.5%	5.1%
7	30 < x ≤ 35	13.2%	1.6%	13.2%	1.6%	13.3%	1.6%	7.2%	3.3%	7.2%	3.3%	7.2%	3.3%
8	35 < x ≤ 40	12.2%	0.9%	12.2%	0.9%	12.2%	0.9%	6.4%	2.2%	6.4%	2.2%	6.3%	2.2%
9	40 < x ≤ 45	0.9%	0.5%	0.9%	0.5%	0.9%	0.5%	2.6%	1.5%	2.6%	1.5%	2.6%	1.5%
10	45 < x ≤ 50	0.0%	0.3%	0.0%	0.3%	0.0%	0.3%	2.3%	1.0%	2.3%	1.0%	2.3%	1.0%
11	50 < x ≤ 55	1.5%	0.2%	1.5%	0.2%	1.5%	0.2%	3.5%	0.7%	3.5%	0.7%	3.5%	0.7%
12	55 < x ≤ 60	5.4%	0.1%	5.4%	0.1%	5.5%	0.1%	2.7%	0.5%	2.7%	0.5%	2.7%	0.5%
13	60 < x ≤ 65	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%	2.4%	0.4%	2.4%	0.4%	2.4%	0.4%
14	65 < x ≤ 70	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%	0.4%	0.3%	0.4%	0.3%	0.4%	0.3%
15	70 < x ≤ 75	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%	0.2%	1.0%	0.2%	1.0%	0.2%
16	75 < x	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.1%	0.1%	2.1%	0.1%	2.1%	0.1%

Table 71: Observed Statistics and Results for Log Normal Distribution Function of Treatment Crash Data for an Adult Walking With Traffic in S4 During the Day With No Obstruction for OEM 1

Variable		OEM 1					
		GES Cases			FARS Cases		
		AEB	First	Best	AEB	First	Best
Mean	μ	0.60	0.60	0.60	1.03	1.03	1.03
Standard Deviation	σ	0.38	0.38	0.38	0.69	0.68	0.69
Probability of Crash		30%	31%	30%	78%	78%	78%

Speed Bin (mph)		GES Cases						FARS Cases					
		AEB Only		First Brake		Best Brake		AEB Only		First Brake		Best Brake	
		Actual	Curve	Actual	Actual	Curve	Actual	Actual	Curve	Actual	Curve	Actual	Curve
1	0 < x ≤ 5	2.8%	29.8%	2.9%	29.4%	3.1%	29.8%	0.6%	18.9%	0.7%	18.8%	0.7%	18.9%
2	5 < x ≤ 10	68.0%	50.9%	66.3%	51.5%	67.4%	50.9%	11.1%	25.7%	10.7%	25.8%	11.1%	25.7%
3	10 < x ≤ 15	3.5%	15.0%	5.5%	14.8%	3.4%	15.1%	36.8%	19.3%	36.7%	19.3%	36.7%	19.2%
4	15 < x ≤ 20	5.3%	3.2%	5.2%	3.0%	5.3%	3.2%	17.1%	12.7%	17.5%	12.7%	17.1%	12.7%
5	20 < x ≤ 25	9.6%	0.6%	9.5%	0.6%	9.8%	0.6%	3.9%	8.1%	4.1%	8.1%	3.8%	8.1%
6	25 < x ≤ 30	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%	2.6%	5.2%	2.6%	5.2%	2.6%	5.2%
7	30 < x ≤ 35	3.6%	0.0%	3.5%	0.0%	3.7%	0.0%	3.7%	3.4%	3.6%	3.4%	3.7%	3.4%
8	35 < x ≤ 40	7.3%	0.0%	7.0%	0.0%	7.2%	0.0%	8.1%	2.3%	8.0%	2.3%	8.1%	2.3%
9	40 < x ≤ 45	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.7%	1.5%	3.8%	1.5%	3.8%	1.5%
10	45 < x ≤ 50	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.3%	1.0%	3.2%	1.0%	3.3%	1.0%
11	50 < x ≤ 55	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.3%	0.7%	2.3%	0.7%	2.3%	0.7%
12	55 < x ≤ 60	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.6%	0.5%	2.6%	0.5%	2.6%	0.5%
13	60 < x ≤ 65	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.4%	0.8%	0.4%	0.8%	0.4%
14	65 < x ≤ 70	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.3%	0.0%	0.3%
15	70 < x ≤ 75	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.2%	0.0%	0.2%
16	75 < x	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.4%	0.1%	3.4%	0.1%	3.4%	0.1%

Table 72: Observed Statistics and Results for Log Normal Distribution Function of Treatment Crash Data for an Adult Walking With Traffic in S4 During the Day With No Obstruction for OEM 2

Variable		OEM 2					
		GES Cases			FARS Cases		
		AEB	First	Best	AEB	First	Best
Mean	μ	0.00	0.49	0.00	0.96	0.95	0.96
Standard Deviation	σ	0.00	0.16	0.00	0.72	0.71	0.72
Probability of Crash		0%	1%	0%	41%	42%	41%

Speed Bin (mph)		GES Cases						FARS Cases					
		AEB Only		First Brake		Best Brake		AEB Only		First Brake		Best Brake	
		Actual	Curve	Actual	Actual	Curve	Actual	Actual	Curve	Actual	Curve	Actual	Curve
1	0 < x ≤ 5	0.0%	0.0%	37.5%	1.8%	0.0%	0.0%	0.2%	22.7%	0.5%	23.0%	0.4%	22.7%
2	5 < x ≤ 10	0.0%	0.0%	60.0%	57.1%	0.0%	0.0%	25.8%	26.0%	26.3%	26.2%	25.4%	25.9%
3	10 < x ≤ 15	0.0%	0.0%	2.5%	0.1%	0.0%	0.0%	35.2%	18.2%	34.9%	18.2%	35.5%	18.2%
4	15 < x ≤ 20	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.6%	11.7%	11.4%	11.6%	11.3%	11.7%
5	20 < x ≤ 25	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.4%	0.0%	7.3%	0.0%	7.4%
6	25 < x ≤ 30	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.7%	0.0%	4.7%	0.2%	4.7%
7	30 < x ≤ 35	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	14.9%	3.1%	14.7%	3.0%	14.8%	3.1%
8	35 < x ≤ 40	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.0%	0.0%	2.0%	0.0%	2.1%
9	40 < x ≤ 45	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.8%	1.4%	3.8%	1.4%	3.9%	1.4%
10	45 < x ≤ 50	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%	0.0%	0.9%	0.0%	1.0%
11	50 < x ≤ 55	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0%	0.7%	3.9%	0.7%	4.0%	0.7%
12	55 < x ≤ 60	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.5%	0.1%	0.5%	0.1%	0.5%
13	60 < x ≤ 65	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	0.1%	0.3%	0.1%	0.4%
14	65 < x ≤ 70	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.2%	0.0%	0.3%
15	70 < x ≤ 75	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.2%	0.0%	0.2%
16	75 < x	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.3%	0.1%	4.2%	0.1%	4.3%	0.1%

Table 73: Observed Statistics and Results for Log Normal Distribution Function of Treatment Crash Data for an Adult Walking With Traffic in S4 During the Day With No Obstruction for OEM 3

Variable		OEM 3					
		GES Cases			FARS Cases		
		AEB	First	Best	AEB	First	Best
Mean	μ	0.78	0.81	0.93	0.98	0.98	0.98
Standard Deviation	σ	0.40	0.39	0.48	0.70	0.70	0.70
Probability of Crash		5%	4%	4%	54%	54%	54%

Speed Bin (mph)		GES Cases						FARS Cases					
		AEB Only		First Brake		Best Brake		AEB Only		First Brake		Best Brake	
		Actual	Curve	Actual	Actual	Curve	Actual	Actual	Curve	Actual	Curve	Actual	Curve
1	**0 < x ≤ 5**	7.4%	15.0%	2.3%	12.3%	9.8%	12.6%	0.1%	21.5%	0.0%	21.6%	0.1%	21.6%
2	**5 < x ≤ 10**	49.7%	48.9%	51.4%	48.5%	38.8%	36.5%	22.3%	26.2%	23.2%	26.1%	23.4%	26.1%
3	**10 < x ≤ 15**	27.4%	24.1%	29.9%	25.7%	22.9%	26.1%	38.5%	18.7%	37.5%	18.6%	36.8%	18.6%
4	**15 < x ≤ 20**	0.2%	7.8%	0.3%	8.6%	10.5%	13.3%	14.5%	12.0%	14.6%	12.0%	15.1%	12.0%
5	**20 < x ≤ 25**	9.7%	2.3%	9.9%	2.6%	11.3%	6.2%	1.2%	7.6%	1.2%	7.6%	1.2%	7.6%
6	**25 < x ≤ 30**	0.0%	0.7%	0.0%	0.7%	0.0%	2.8%	0.0%	4.8%	0.0%	4.8%	0.0%	4.8%
7	**30 < x ≤ 35**	5.6%	0.2%	6.2%	0.2%	6.7%	1.3%	8.1%	3.1%	8.1%	3.1%	8.4%	3.1%
8	**35 < x ≤ 40**	0.0%	0.1%	0.0%	0.1%	0.0%	0.6%	5.5%	2.1%	5.5%	2.1%	5.2%	2.1%
9	**40 < x ≤ 45**	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	1.6%	1.4%	1.6%	1.4%	1.6%	1.4%
10	**45 < x ≤ 50**	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	1.5%	1.0%	1.5%	1.0%	1.5%	1.0%
11	**50 < x ≤ 55**	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	3.1%	0.7%	3.1%	0.7%	3.1%	0.7%
12	**55 < x ≤ 60**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.5%	0.1%	0.5%	0.1%	0.5%
13	**60 < x ≤ 65**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	0.1%	0.3%	0.1%	0.3%
14	**65 < x ≤ 70**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.2%	0.0%	0.2%
15	**70 < x ≤ 75**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.2%	0.0%	0.2%
16	**75 < x**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.4%	0.1%	3.4%	0.1%	3.4%	0.1%

APPENDIX G: BASELINE VS. TREATMENT CURVES

This appendix plots the results from the PCAM simulation (with AEB only) compared to the baseline for the respective PCAM scenario. The 'AEB only' treatment condition was selected, as this is the minimal system that would be implemented. As seen from the results from Section 4 and Appendix F, a warning yielded minimal improvement compared to the AEB only treatment condition; this is due to the limited time between warning and AEB activation (< 1 s) allowing for a small population of drivers to respond.

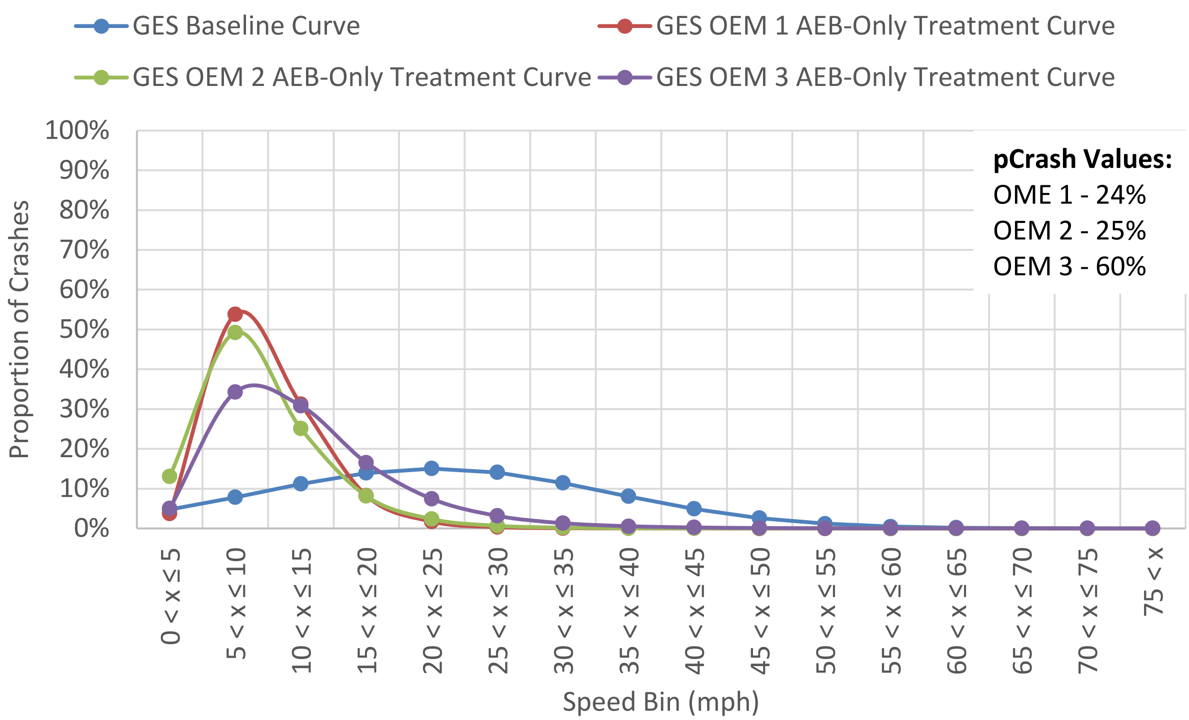

Figure 33: Plots of Functions Comparing GES Baseline to GES Treatment for AEB Only Results Data for an Adult Walking in S1 During the Day With No Obstruction for All OEMs

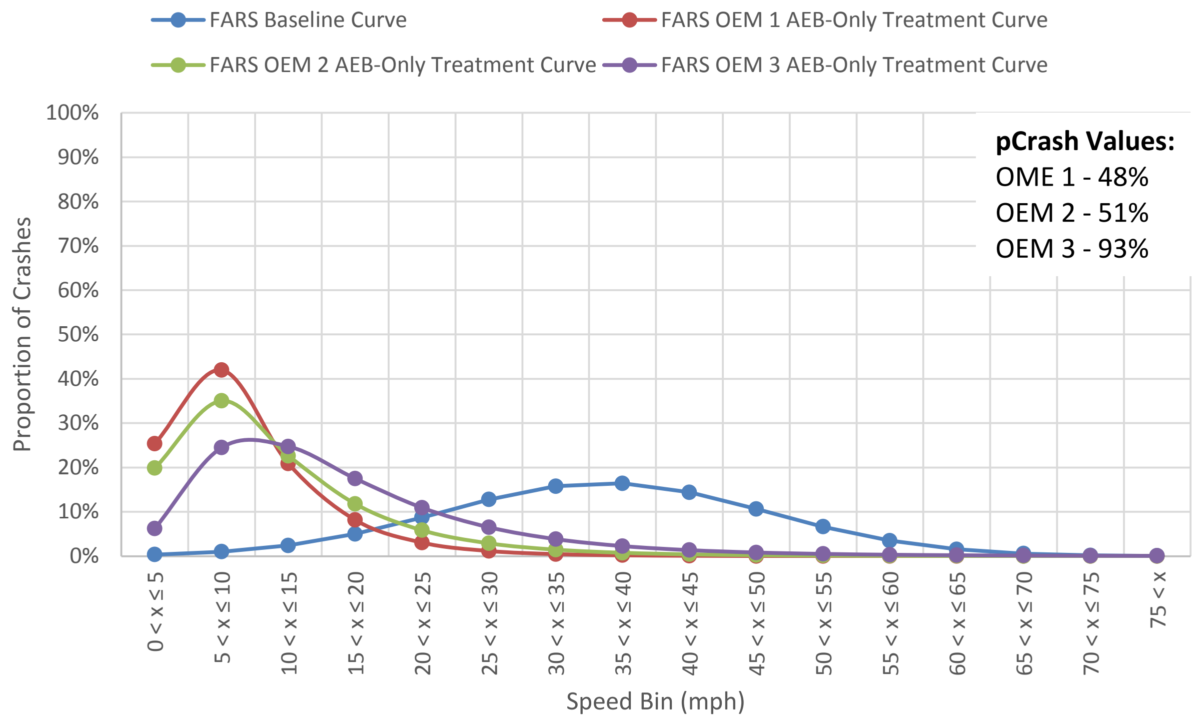

Figure 34: Plots of Functions Comparing FARS Baseline to FARS Treatment for AEB Only Results Data for an Adult Walking in S1 During the Day With No Obstruction for All OEMs

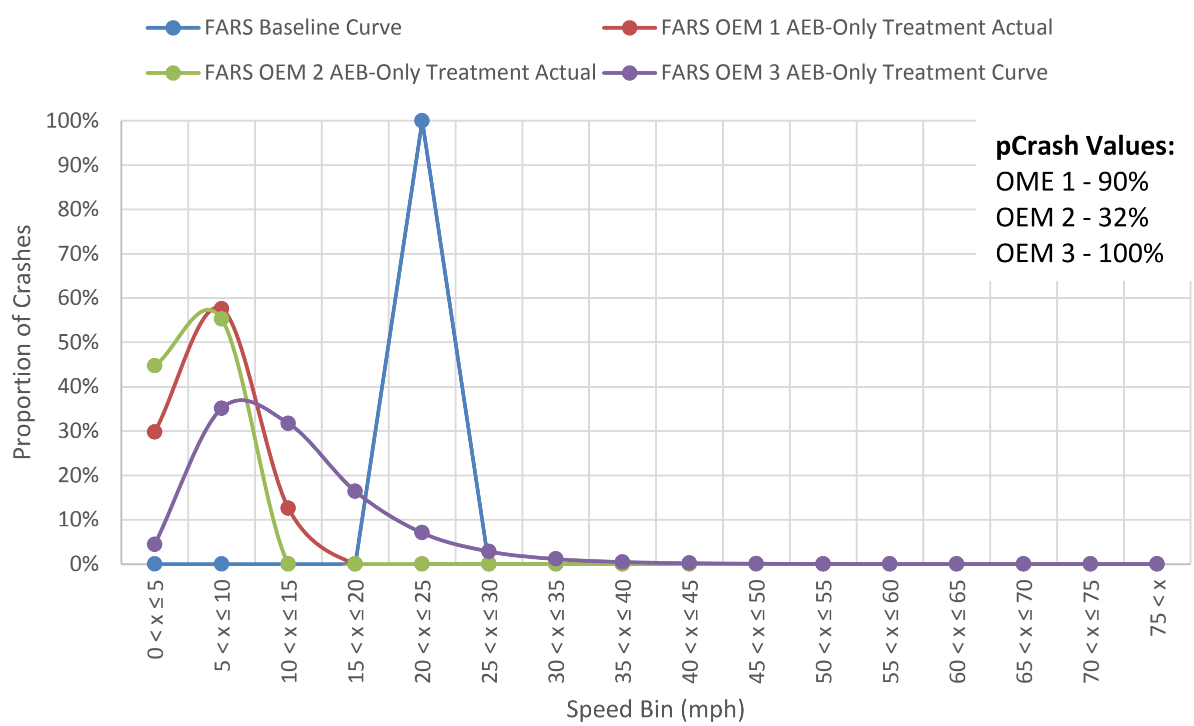

Figure 35: Plots of Functions Comparing FARS Baseline to FARS Treatment for AEB Only Results Data for an Adult Running in S1 During the Day With No Obstruction for All OEMs

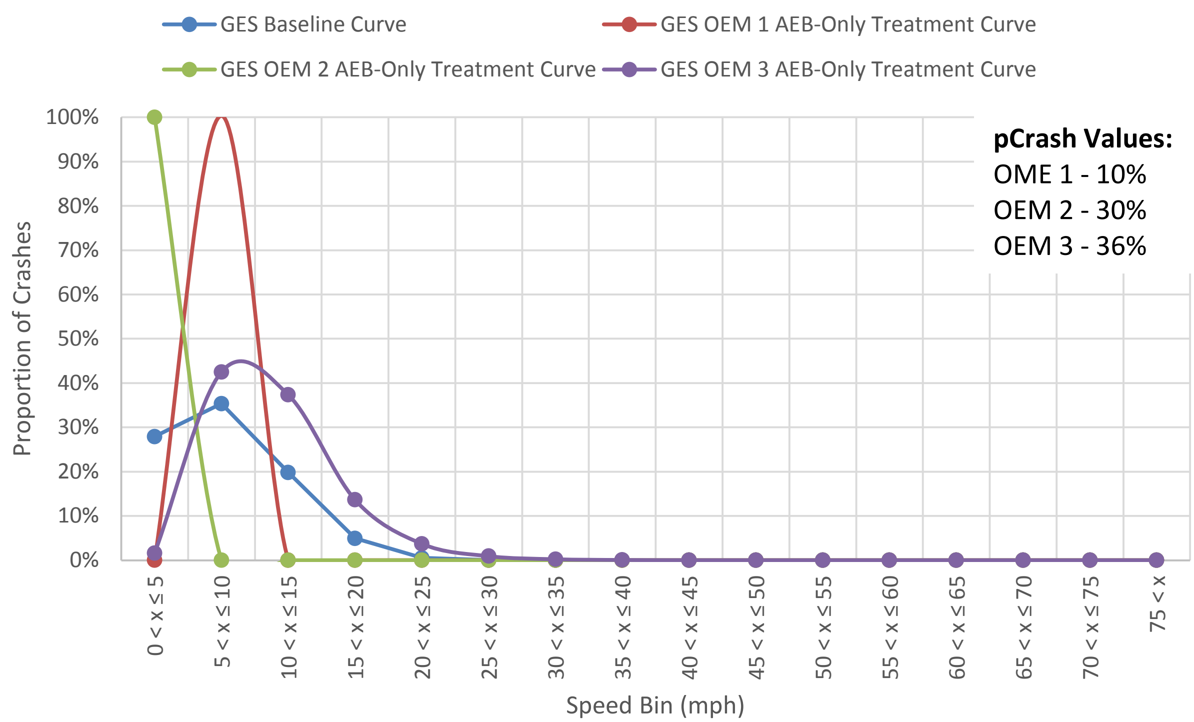

Figure 36: Plots of Functions Comparing GES Baseline to GES Treatment for AEB Only Results Data for a Child Walking in S1 During the Day With No Obstruction for All OEMs

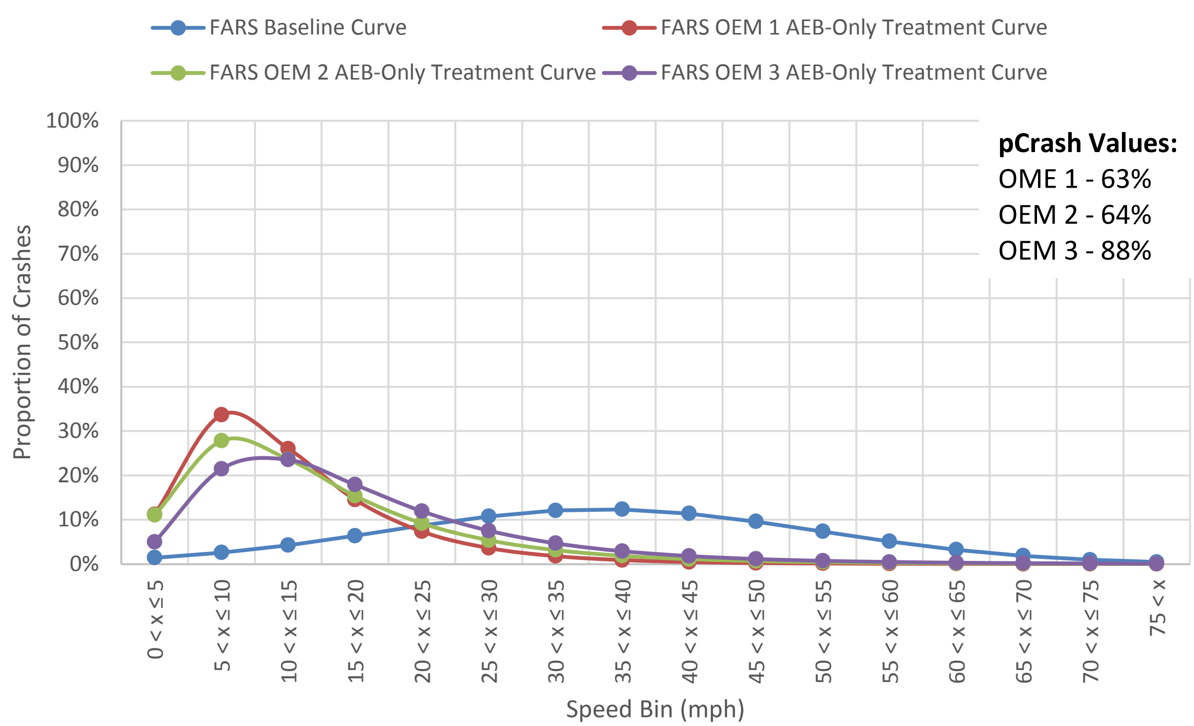

Figure 37: Plots of Functions Comparing FARS Baseline to FARS Treatment for AEB Only Results Data for a Child Walking in S1 During the Day With No Obstruction for All OEMs

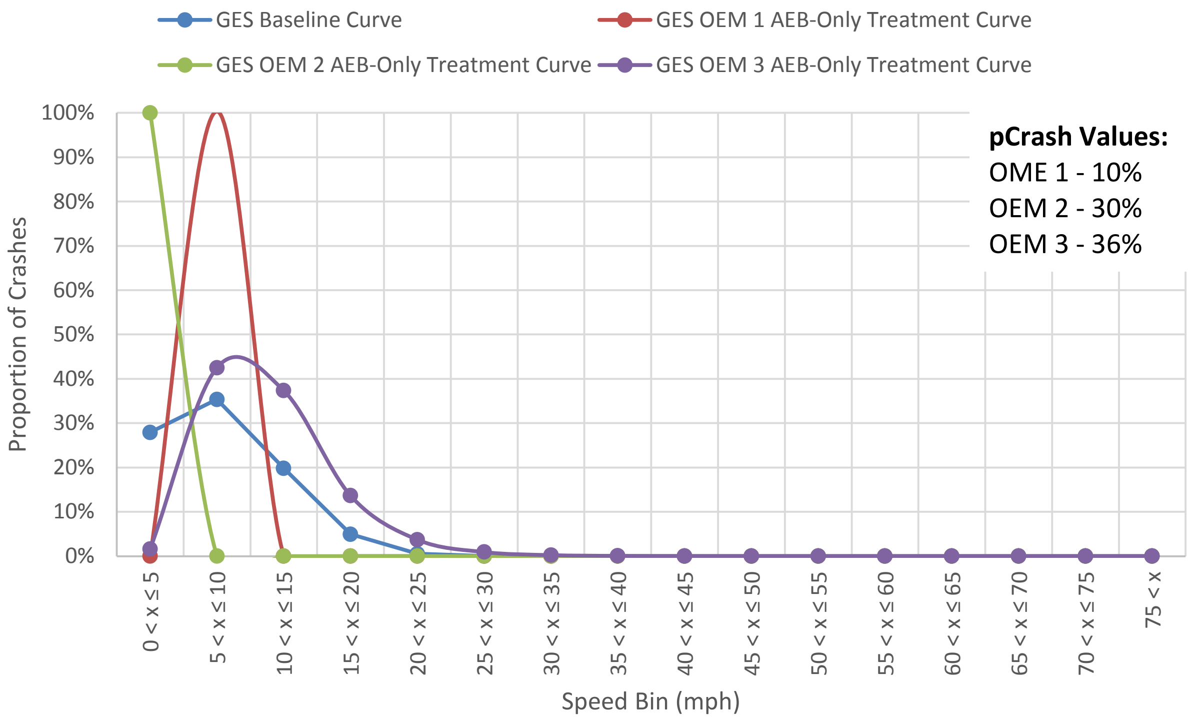

Figure 38: Plots of Functions Comparing GES Baseline to GES Treatment for AEB Only Results Data for a Child Walking in S1 During the Day With No Obstruction for All OEMs

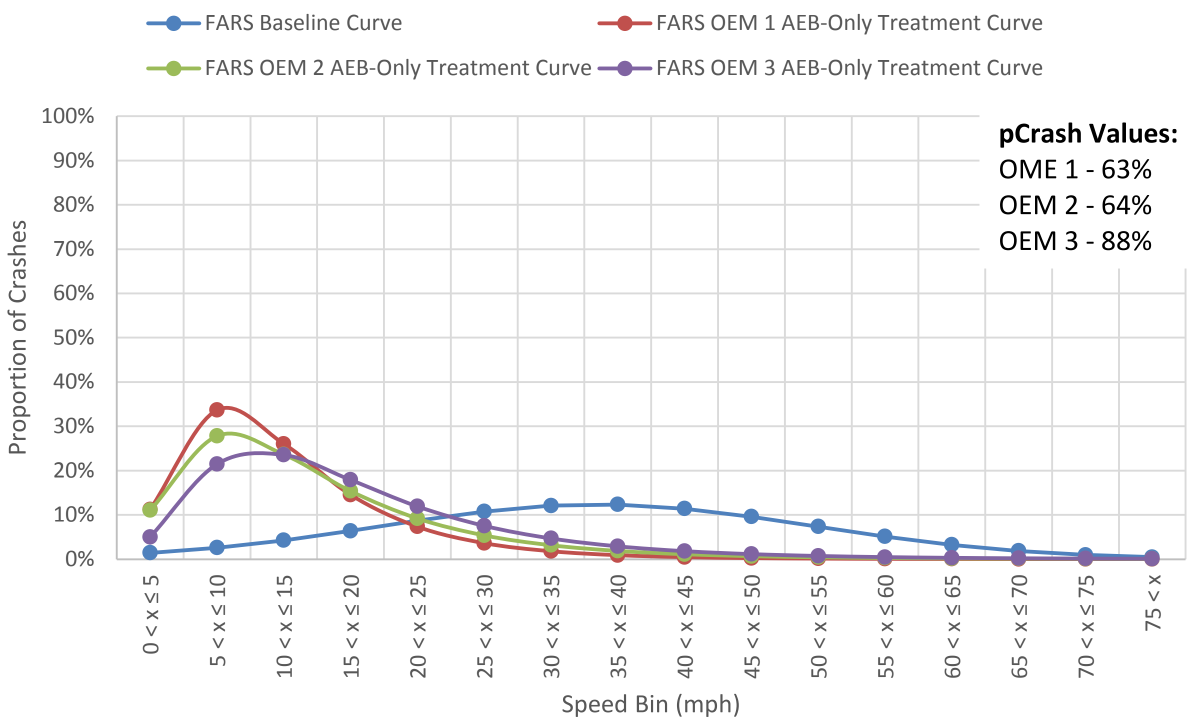

Figure 39: Plots of Functions Comparing FARS Baseline to FARS Treatment for AEB Only Results Data for a Child Walking in S1 During the Day With No Obstruction for All OEMs

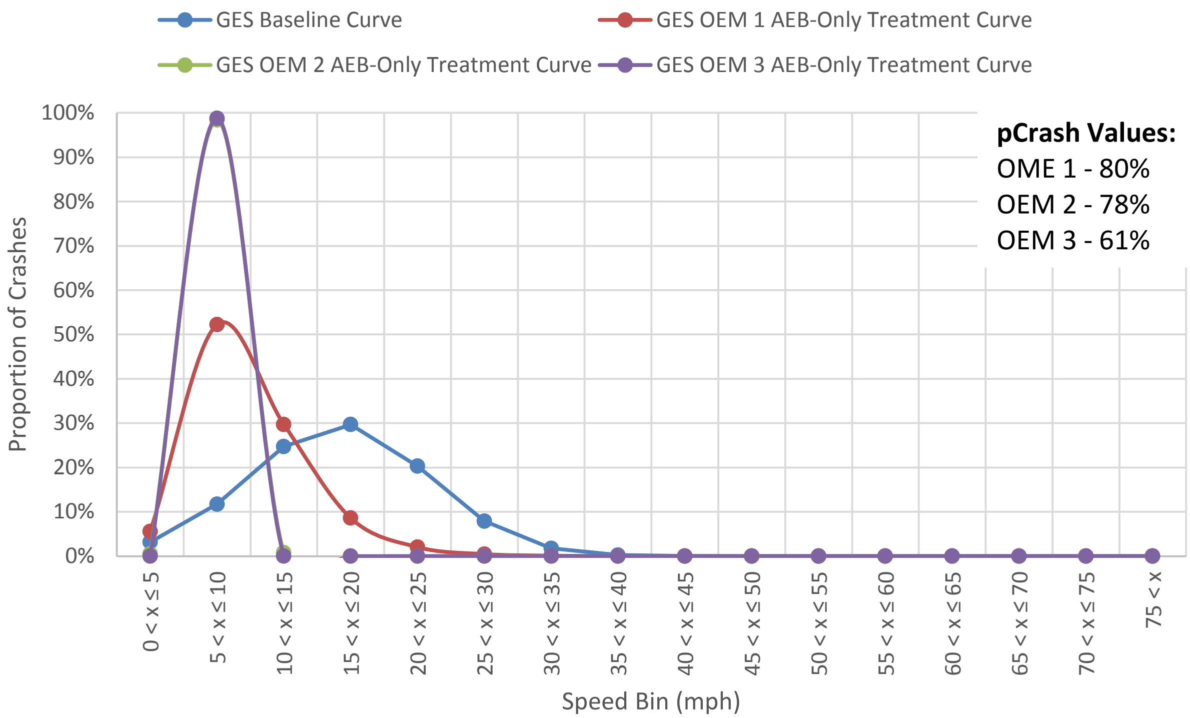

Figure 40: Plots of Functions Comparing GES Baseline to GES Treatment for AEB Only Results Data for a Child Walking in S1 During the Day With an Obstruction for All OEMs

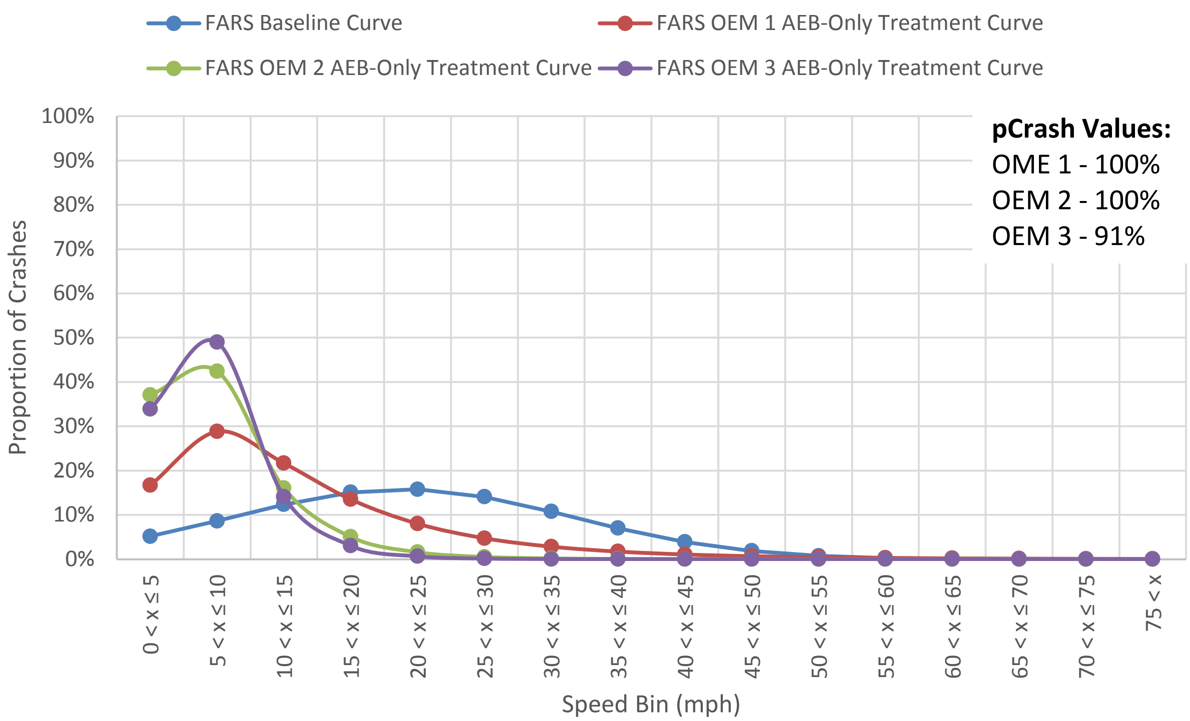

Figure 41: Plots of Functions Comparing FARS Baseline to FARS Treatment for AEB Only Results Data for a Child Walking in S1 During the Day With an Obstruction for All OEMs

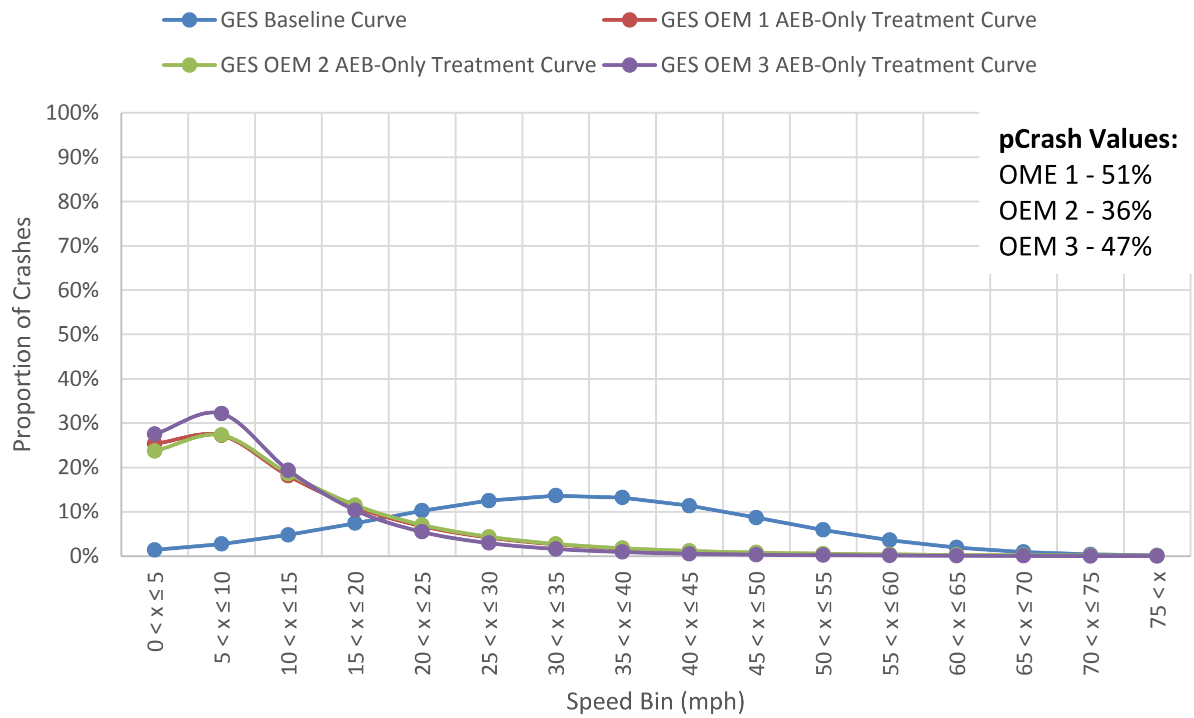

Figure 42: Plots of Functions Comparing GES Baseline to GES Treatment for AEB Only Results Data for an Adult Stationary in S4 During the Day With No Obstruction for All OEMs

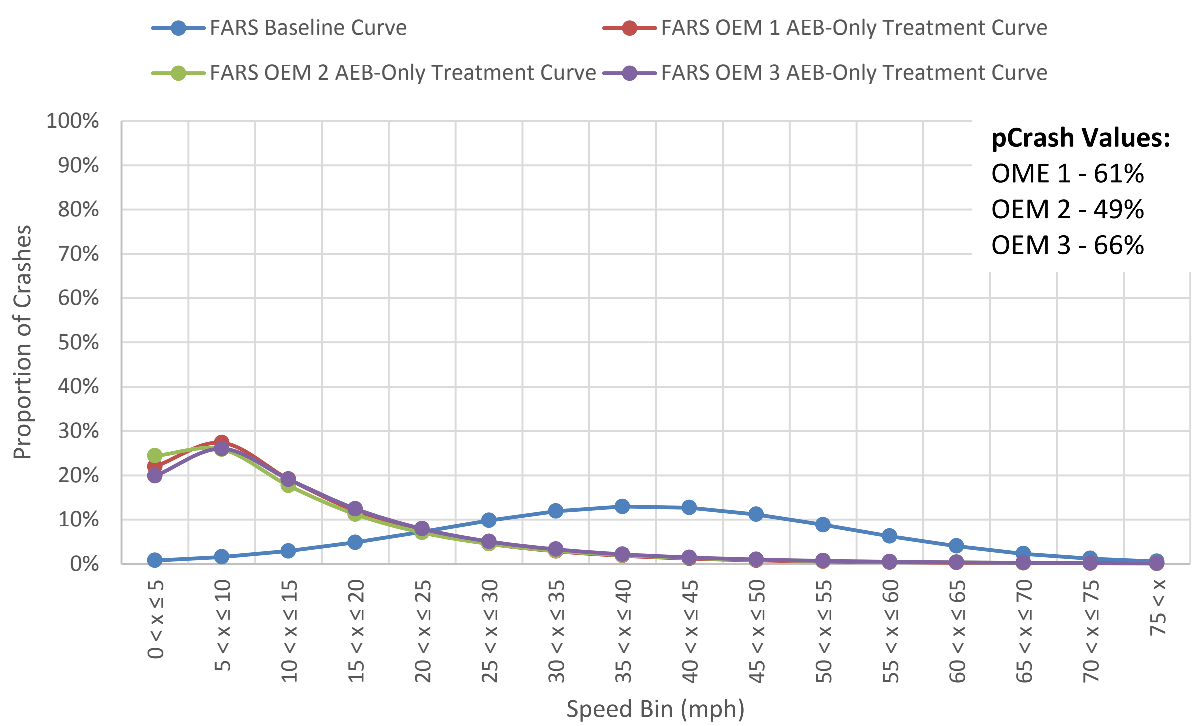

Figure 43: Plots of Functions Comparing FARS Baseline to FARS Treatment for AEB Only Results Data for an Adult Stationary in S4 During the Day With No Obstruction for All OEMs

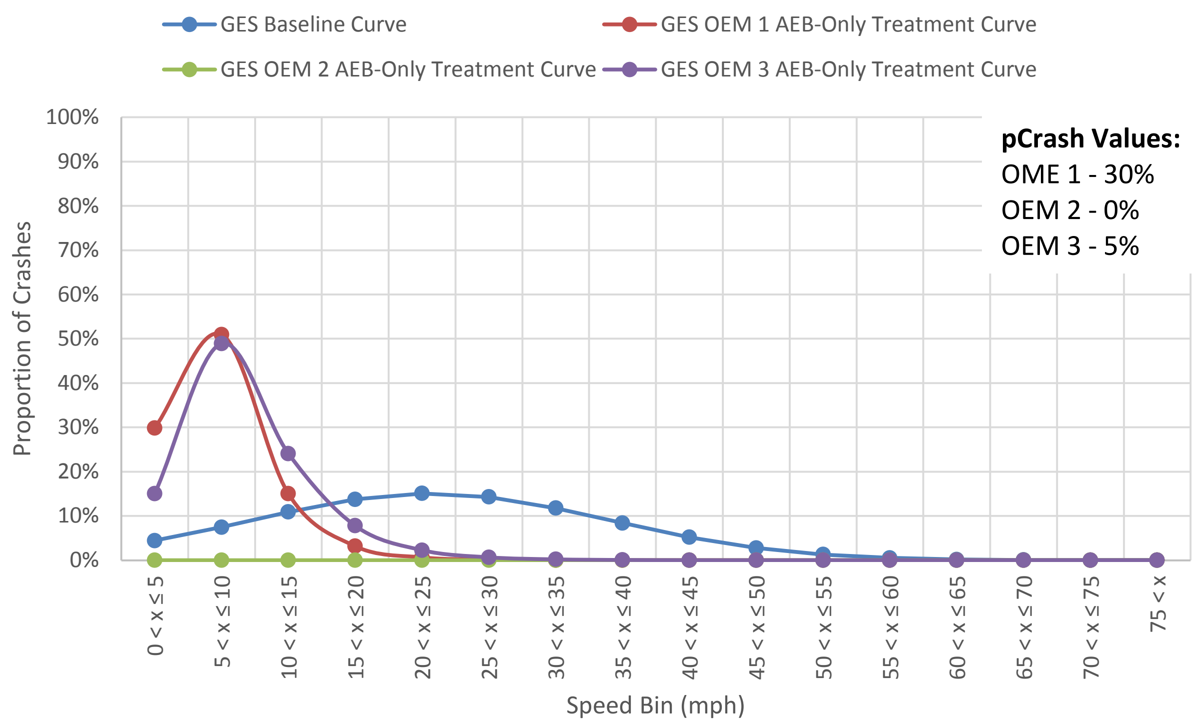

Figure 44: Plots of Functions Comparing GES Baseline to GES Treatment for AEB Only Results Data for an Adult Walking With Traffic in S4 During the Day With No Obstruction for All OEMs

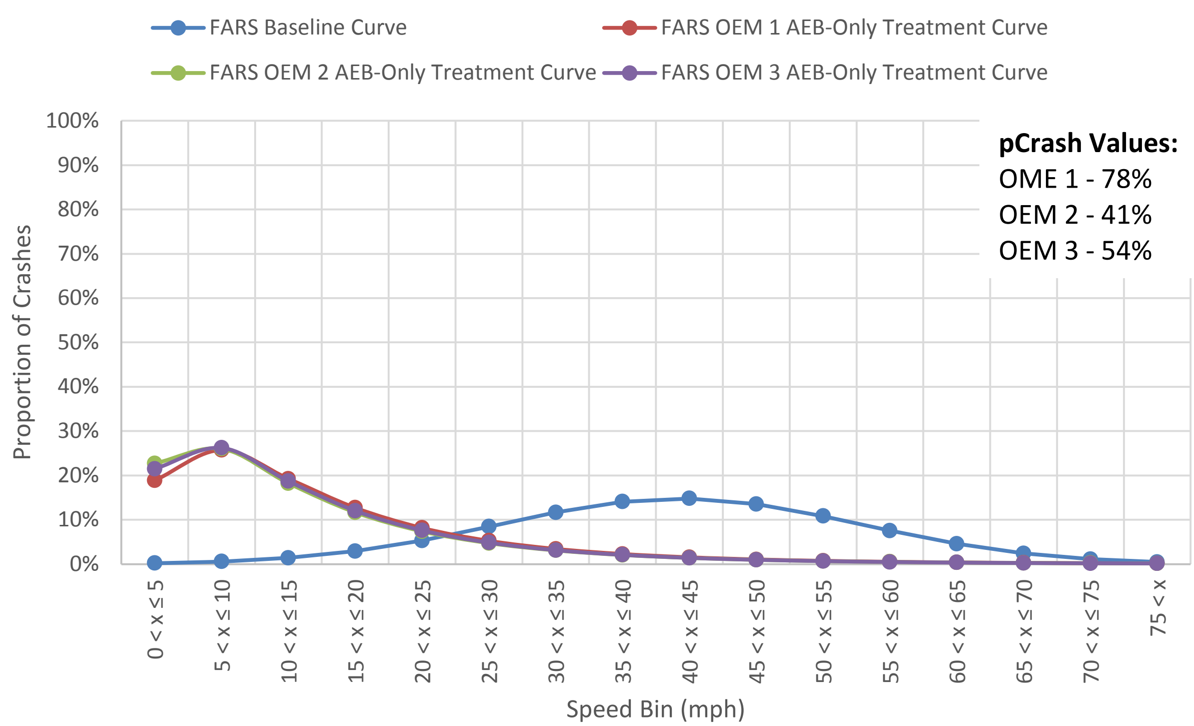

Figure 45: Plots of Functions Comparing FARS Baseline to FARS Treatment for AEB Only Results Data for an Adult Walking With Traffic in S4 During the Day With No Obstruction for All OEMs

APPENDIX H: SIMULATION SENSITIVY ANALYSIS

A Monte Carlo analysis uses distribution inputs into a numerical simulation to obtain a steady state result. The number and type of input distributions will affect the accuracy and precision of the outcome. For this analysis, the number and type of input distributions were fixed (i.e., baseline crashes and system performance results). Therefore, a simple sensitivity analysis was conducted for an appropriate number of "instances" or "iterations" to run within the Monte Carlo simulation so that a steady state was reached.[48] A steady state was defined as a minimal fluctuation of results when repeating a simulation.

The simulation was run with variations in number of iterations for the test scenario with the greatest number of correlating FARS and GES cases and the test scenario with the least number. An adult walking during the day with no obstruction in an S1 was chosen because it had the most cases available for reconstruction, 116 GES cases and 741 FARS cases. As shown in Figure 46, the simulation results reach a steady state beyond 2,500 iterations. For this analysis, a steady state can be defined within a ± 0.2 percent range.

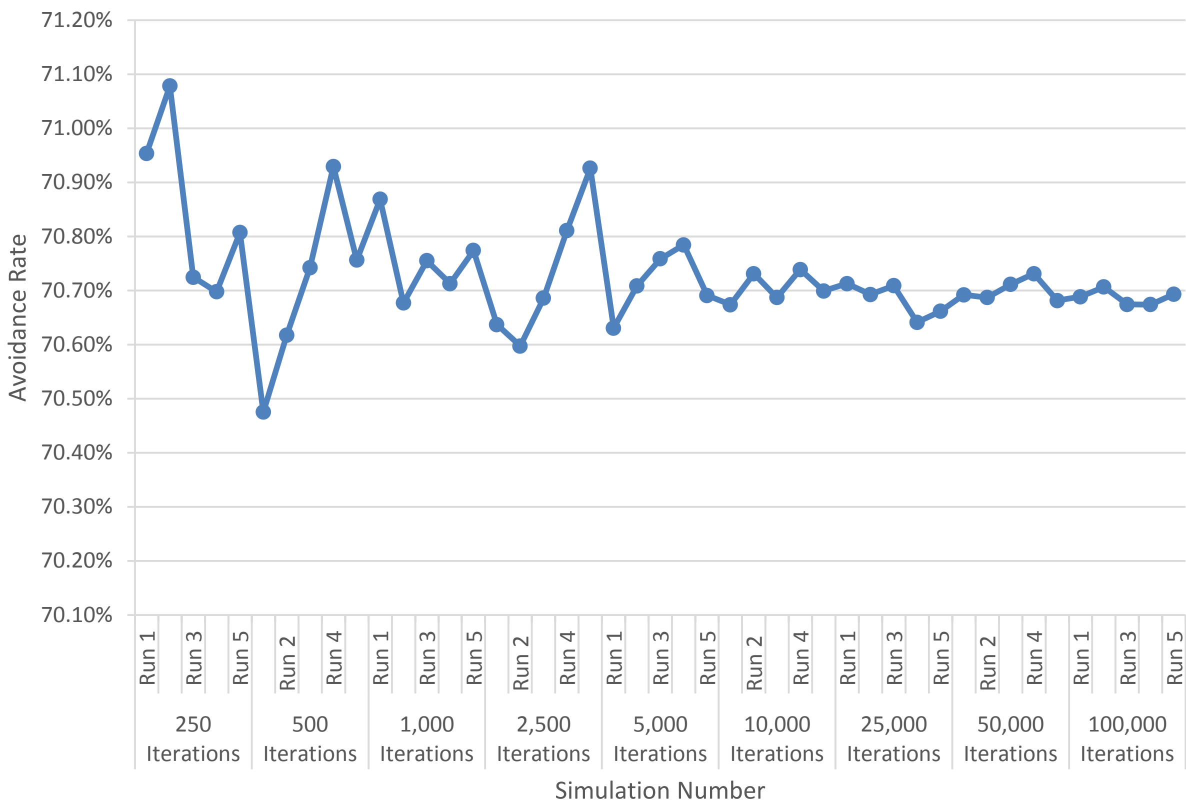

Figure 46: Sensitivity of Number of Iterations for a Sample S1 Simulation

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[48] Iterations refer to the number of times a single baseline crash was reconstructed with superimposed system performance data.

Similarly, a child walking during the day with an obstruction in an S1 was chosen because it had minimal cases available for reconstruction, 6 GES cases and 11 FARS cases.[49] As shown in Figure 47, the simulation results reach a steady state beyond 50,000 iterations (i.e., within a ± 0.2 percent range.

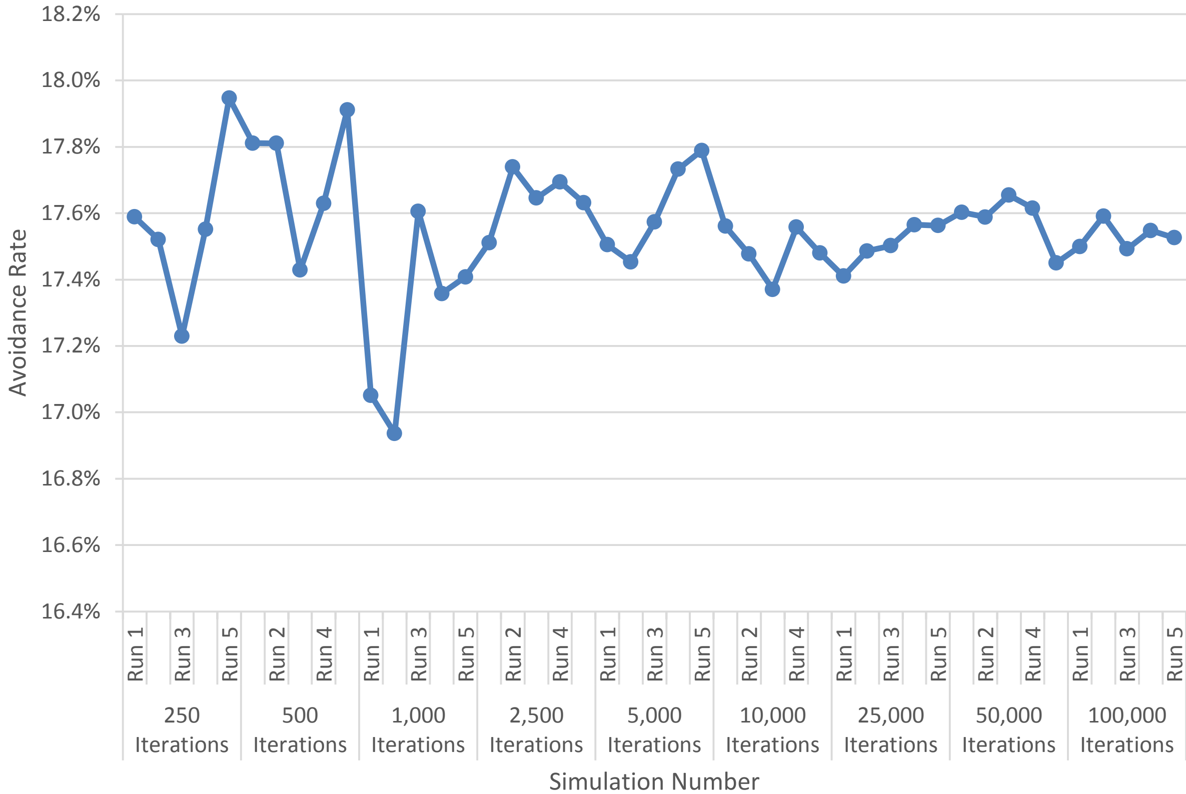

Figure 47: Sensitivity of Number of Iterations for a Sample S4 Simulation

All test scenarios were simulated for 100,000 iterations for consistency within the analysis and to ensure precise results with least number of cases.

[49] Although an adult running in an S1 during the day with no obstruction had the true minimum of cases (0 GES and 1 FARS). This scenario was not chosen as to maximize the number of input variables, but minimize the variations and distributions of these input variables.

APPENDIX I: WARNING SENSITIVITY ANALYSIS

As noted in Section 4 there were minimal improvements in PCAM systems when a warning was issued in addition to AEB activation. Almost all three treatment conditions (AEB only, first braking, and best braking) yielded similar crash counts and crash distributions from the simulation. This is most likely due to the results described in Section System Performance Results3.2.4, where a warning was issued almost simultaneously with AEB activation (on average the warning occurred less than 0.5 s prior to AEB activation). This small window allows for little driver intervention, regardless of magnitude. A small percentage of drivers react in this time frame, as described in Section 3.3 (log normal distribution with an average of 1.1 s reaction time and 0.3 standard deviation).

This report presents results for the three treatment conditions but presents the AEB only treatment condition as the lower limit for system effectiveness. However, a warning and earlier braking could provide improved crash avoidance and mitigation. Although the production vehicles did not support this theory, a sensitivity experiment was conducted. To exercise this idea and to demonstrate the potential improvement (or consequences) of a two-staged PCAM system (warning plus AEB) compared to a single-staged PCAM system (AEB only) simulations were run on various warning timings, compared to AEB activation. The sensitivity analysis adjusts the warning time relative to the AEB timing (e.g., warning issued 0 s prior to AEB, warning issued 0.25 s prior to AEB, warning issued 0.5 s prior to AEB, etc.…) to illustrate any differences between the two systems. The simulation was run on the most common test scenario within the two major pre-crash scenarios (S1 and S4). The results are plotted in the following charts for crash avoidance across the two databases.

Although at varying degrees of effectiveness, the same trend occurs. If the warning is issued at the same time as AEB activation, there is no room for driver response and therefore all three treatment conditions yield equivalent results. The first instance of discrepancy is shown at the 0.75 s interval (the warning is issued 0.75 s prior to AEB). It is easy to see that the best braking improves beyond AEB; earlier potential driver braking and then higher AEB braking (on average the AEB had higher braking levels than a driver). However, it is interesting to see that the first braking response treatment condition actually provides more crashes than the AEB. At first glance this may seem counterintuitive. After considering the average driver performance (1.1 s reaction time and 0.3 g braking level), it can be deduced that the overall braking performance of the system (driver plus AEB) during the potentially extended braking period is worse with lower driver braking than with a shorter time frame of higher AEB braking. This trend reverses around the 1.75 s mark (warning is issued 1.75 s prior to AEB), as now the longer duration of lower braking performance exceeds that of the shorter duration harder braking. Extending this idea further out into time, at some point the best braking and first braking treatment conditions will converge as well (> 3 s). Logically, the best braking performance system is the most effective, however using a first braking response yields better results than the AEB only condition only when the driver has ample time to respond.

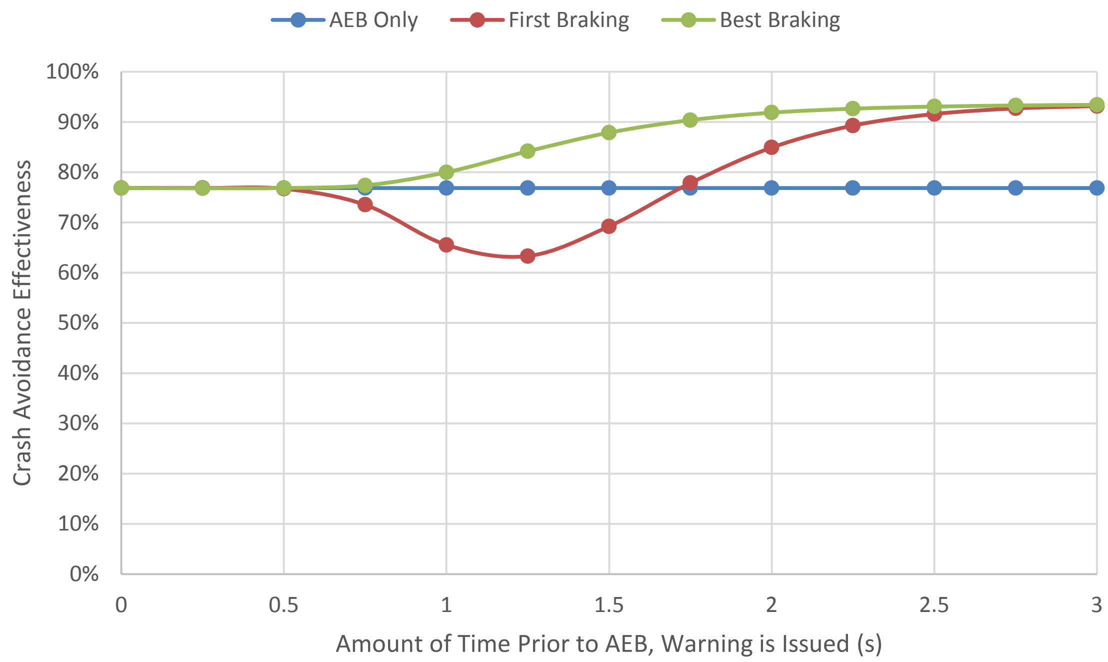

Figure 48: GES Adult Walking in S1 During the Day With No Obstruction for OEM 1

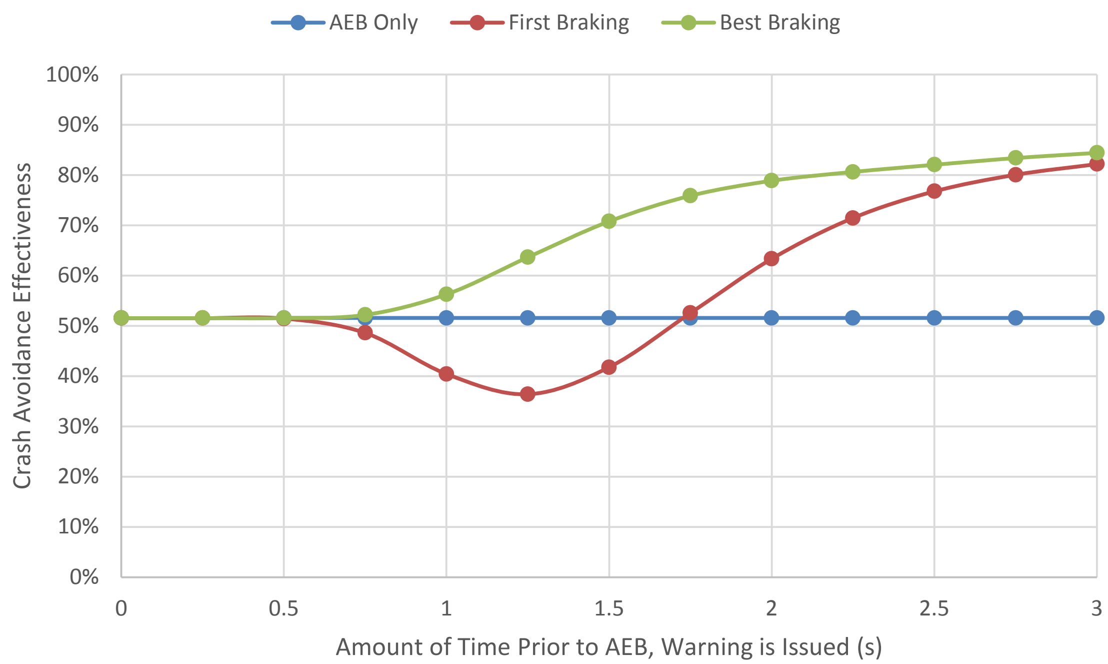

Figure 49: FARS Adult Walking in S1 During the Day With No Obstruction for OEM 1

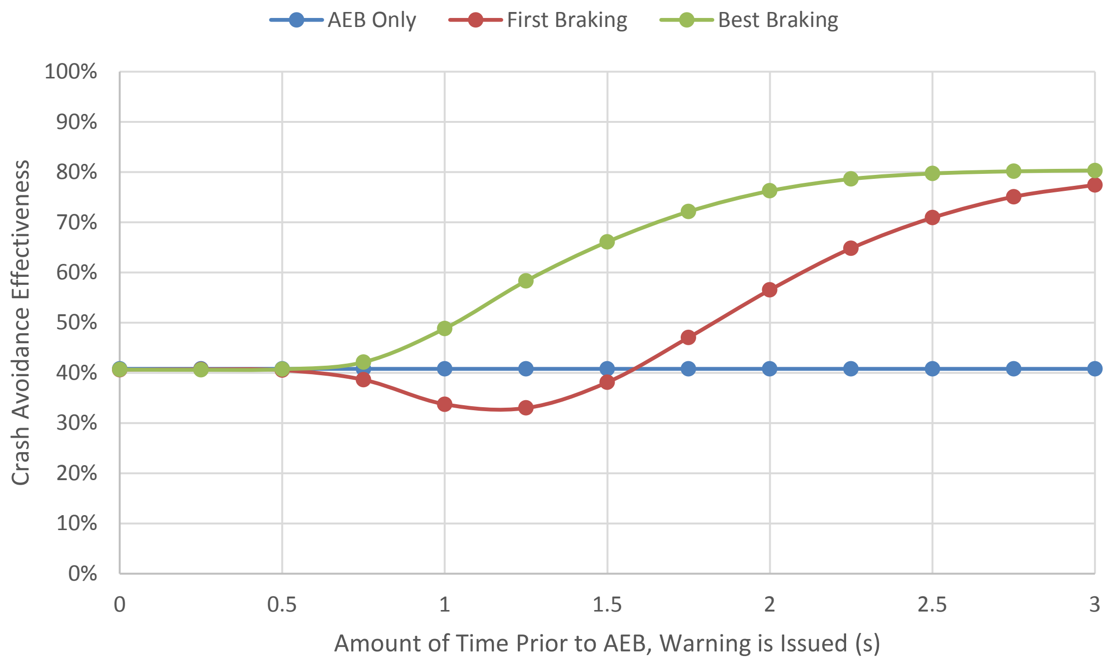

Figure 50: GES Adult Stationary in S4 During the Day With No Obstruction for OEM 1

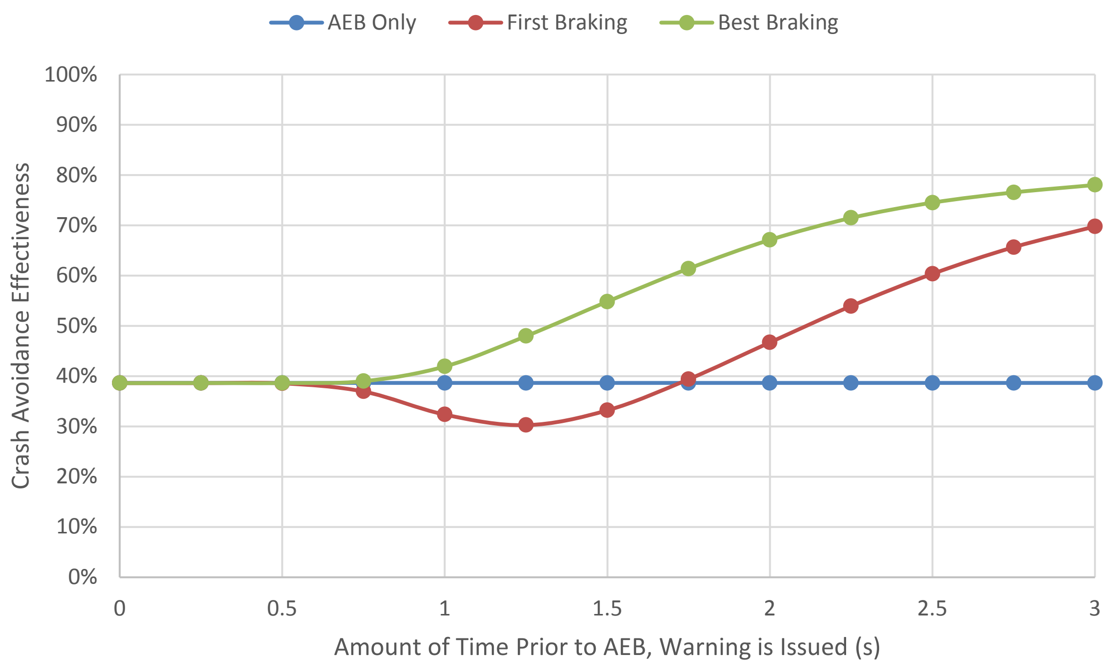

Figure 51: FARS Adult Stationary in S4 During the Day With No Obstruction for OEM 1

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