Accident and Injury Causation Analysis

How to Use Accident Statistics Effectively

By

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Short Paper PCB 3 - 2012

December 2012

www.pcbrakeinc.com

Introduction

In the paper the authors review research findings that date back to the mid-70s while working with the accident research team at the University of Utah. We were particularly interested in analyzing accident avoidance potentials (vehicle handling and braking), as well as maintenance and related vehicle factors on accident causation. Compared to the early limited data bases, modern FARS and NASS statistical data bases can become "real gold mines", when properly understood and queried by a qualified expert.

Throughout the paper we make reference to the text *Motor Vehicle Accident Reconstruction and Cause Analysis*, by Rudolf Limpert, now in its seventh edition published by LexisNexis. The software accompanying the text is MARC1-2013 available from our website pcbrakeinc.com.

Epistemology or System of Inquiry in Data Collection

Juries render verdicts based on a variety of factors which are often not fully understood, and more importantly, not easily predicted. A case whose outcome is nearly certain most likely will be settled after critical data have been collected and analyzed by all parties involved. In more complex cases the party who does the "home work" for the jury or judge has a better chance of being successful. Doing the home work means to find the truth no matter what the source is. Some times this activity is referred as epistemology, or the system of inquiry employed by an expert or lawyer.

Frequently, cases are decided by objective "outside" data such as accident statistics and/or general non-case specific test or research data, primarily conducted by federal governmental agencies such as the National Highway Traffic Safety Administration (NHTSA). Many federal and other research studies address specific subjects relating to what drivers can do to avoid an accident. For example, when a cruise control does not shut off when the driver applies the brake pedal, these studies tend show that after a normal reaction time of 1.5 seconds, the driver can place the transmission in neutral. The same conclusion is often drawn in the case of a sudden rear tire tread separation, when after a normal reaction time the driver can regain control of the vehicle by a correct steering input. However, these studies do not show anything about what real drivers under real driving conditions will or will not do in an attempt to avoid a crash. In order to find out what real drivers will do, accident statistical data must be analyzed carefully by an expert experienced in accident data systems, accident reconstruction and vehicular factors.

Many times juries are looking for testimony that helps them in finding the underlying truth of the matter. Accident statistical data that are related to the specific case under consideration but were collected by an uninvolved organization on a routine basis and their proper and meaningful analysis by a qualified expert many times provide the assistance a jury is so desperately looking for.

Many times showing that what appears to be similar quantities can in fact be different. The use of statistics makes this possible. Two very important concepts should be understood, namely: Probability and Significance. Many attorneys use words such as “likely”; “how likely is it ….?” or “Isn’t it possible that the driver made a mistake?” The true meaning of these phrases is: “What is the probability ….?” Example: How likely is it for a belted person to receive injuries to the back in a minor rear end collision?” The correct question is: “What is the probability (%) that a belted person will receive injuries to the back in a minor rear end collision?” It could be 0%, (Never), it could be 100%, (Always); or it is a specific % based on data analysis. “Likely” or “Not likely” would probably have no helpful meaning for jurors.

Tests such as the Chi Square test or the Student “t” test are used in statistics to see if two quantities are significantly different or not. In the above example, the jurors might want to know if being belted or not makes a difference for a particular case. If the data for the above example showed that 51% of the unbelted passengers were injured and 49% of the belted passengers were injured, is this sufficient information to conclude that if the unbelted passengers had been belted, they would not have been injured?

Thus, a proper data analysis can complement the results of the reconstruction and add factual meaning to the conclusions. It also helps in complying with the degrees of proof.

Degrees of proof: The measure of probability necessary in order for a court or other fact-finder to render a decision or a verdict with regard to the evidence presented to it. Briefly,

Preponderance of evidence, also known as balance of probabilities is the standard required in most civil cases. The standard is met if the proposition is more likely to be true than not true. Effectively, the standard is satisfied if there is greater than 50 % chance that the proposition is true.

Clear and Convincing Evidence, the party with the burden of proof must convince the trier of fact that it is substantially more likely than not that the thing is in fact true. This is a stricter requirement than proof by "Preponderance of the Evidence," which merely requires that the matter asserted pass the 50% threshold of being more likely true than not.

Beyond reasonable doubt is the highest standard used as the burden of proof in criminal proceedings. It has been described as, in negative terms, as a proof having been met if there is no plausible reason to believe otherwise. If there is a real doubt, based upon reason and common sense after careful and impartial consideration of evidence, or lack of evidence, in a case, then the level of proof has not been met. Proof beyond a reasonable doubt, therefore, is proof of such a convincing character that you would be willing to rely and act upon it without hesitation in the most important of your own affairs. However, it does not mean an absolute certainty. The standard that must be met by the prosecution’s evidence in a criminal prosecution is that no other logical explanation can be derived from the facts except that the defendant committed the crime, thereby overcoming the presumption that a person is innocent until proven guilty. The term connotes that evidence establishes a particular point to a moral certainty and that it is beyond dispute that any reasonable alternative is possible. It does not mean that no doubt exists as to the accused's guilt, but only that no Reasonable Doubt is possible from the evidence presented. The main reason that the high proof standard of reasonable doubt is used in criminal trials is that such proceedings can result in the deprivation of a defendant's liberty or even in his or her death. These outcomes are far more severe than in civil trials, in which monetary damages are the common remedy.

Beyond the shadow of a doubt is the strictest standard of proof. It requires that there be no doubt as to the issue. Widely considered an impossible standard, a situation stemming from the nature of knowledge itself, it is valuable to mention only as a comment on the fact that evidence in a court never need (nor can) reach this level. This phrase, has, nonetheless, come to be associated with the law in popular culture.

It can, thus, be inferred that an event that occurs often would be accepted as having a high probability (more than 75%?) to occur again and again, other things being equal.

2012 Accident Statistics

Consider the latest statistics on traffic accidents for 2012, as reported in MSN.com:

New statistics released by the National Highway Traffic Safety Administration reveal a yo-yo in traffic deaths over the past two years. While fatalities dropped to 32,367 in 2011 -- the lowest level since 1949 -- they jumped by 9 percent in the first half of 2012.

What gives? Americans are driving more this year, to put it simply.

Note: The author wrongly assumes that the human factor is entirely at fault. There is no analysis of significance to see if the 9% increase is significantly higher than the average. One event, say involving a bus full of passengers, could drastically affect this percentage.

"In 2011, travel on U.S. roads fell to its lowest level since 2003," David Shepardson writes in The Detroit News. "Last year, U.S. drivers logged 35.7 billion fewer miles over 2010, down 1.2 percent to 2.963 trillion miles."

Note: Is this 1.2% statistically significantly different?

But this year, we're making up for that lost road time. According to NHTSA, drivers logged 15.6 billion more miles behind the wheel in the first six months of 2012, the latest numbers available. That's a 1.1 percent increase.

Note: Is this 1.1% statistically significantly different?

Balmy weather in the first three months of 2012 was likely a factor. As more motorists took advantage of the improved driving conditions, there was a 13.4 percent uptick in *fatalities. Fatality rates for the first six months of the year hit their highest levels since 2009; the increase was the most dramatic since 1979.*

Note: The author now switches the "blame" to the environmental factor. There is no analysis of significance to see if the 13.4% increase is significantly higher than the average.

In 2011, drunk-driving deaths were among those that decreased. But on the flip side, large-truck occupants, bicyclists, pedestrians and motorcyclists were all involved in more accidents. Distracted-driving deaths also increased, by nearly 2 percent.

Note: Is this 2% statistically significantly different?

The overall trend is overwhelmingly positive; fatality rates in 2011 were 26 percent lower than in 2005.

Note: It can be seen that a more in-depth analysis is required before drawing conclusions that can prove misleading.

Pre-Crash-, Crash, and Post-Crash Phases

One of the first German traffic accident reports is located in the main governmental archives of the City of Wiesbaden, Germany under number (1)2971. It reports of a traffic collision which occurred on January 13, 1758 at the gallows hill (Galgenberg) near the City of Wetzlar. A local horse-drawn wagon traveling downhill on a steep grade collided with a horse-drawn carriage traveling uphill. The traffic regulation required to yield the right-of-way to uphill traffic. The records indicate that the uphill carriage was a total loss and its occupants' lives were in danger. But not enough, in the obligatory fist fight that ensued, things went from bad to worse when a hoe was used injuring one of the uphill occupants. After he was able to walk, he complained to the mayor of Wetzlar who promptly threw him and his brother in jail for disturbing the peace and fined them 15 gulden. It took three years before the appeals court ordered Wetzlar to pay damages and repay the fine. The medical expert report was one handwritten sentence by a medical doctor counter-signed by another doctor.

This accident clearly shows the elements involved in accident analysis, namely the human, vehicular and environmental factors. In particular, for the old German case, it reveals specific injury severity increasing factors in the post-crash phase by not properly securing the crash scene after the accident.

Active/Passive Safety Matrix

The pre-crash, crash, and post-crash phases in terms of human, vehicle, and environment factors are shown in the safety matrix (Haddon matrix) as illustrated in Figure 1.

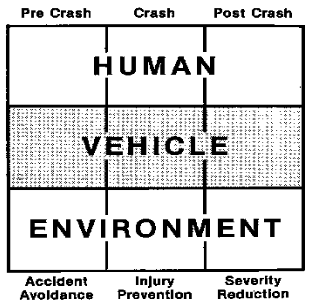

Figure 1: Active/Passive Safety Matrix (Haddon Matrix)

For the reader to understand the elements involved in the safety matrix, and hence, be better prepared to utilize modern accident data bases, the safety matrix will briefly be discussed in terms of active and passive safety.

Active safety refers to any activity in the human, vehicular and environmental sections which will increase safety prior to the crash, while passive safety will do so during and after the crash.

Active Safety and Human Element: Driver education to eliminate critical driver situations, traffic fines, driver alertness, etc.

Active Safety and Vehicle: Predictable vehicle handling, ABS brakes, electronic stability control (ESC), tire tread, optimum interior controls, exterior vehicle recognition, vehicle safety inspections and maintenance, etc.

Active Safety and Environment: Traffic flow control, road design and maintenance, etc.

Passive Safety and Human Element: Use of seat belts, driver/occupant education in medical emergency activities, ambulance services, etc.

Passive Safety and Vehicle: Crashworthiness, occupant protection, crash compatibility, lowering of repair and maintenance costs, etc.

Passive Safety and Environment: Securing accident scene, guard rails, elimination of off-highway obstacles, etc.

When utilizing accident data, the reader must understand that certain data are based upon descriptive information, while others are of objective characteristic. For example accident data that are measurable include tire road friction coefficient, road curvature, skid mark geometry, etc. Objective data may also be collected at a later time such as vehicle weights, road slope, driving records, etc. Descriptive data may include witness statements concerning speed, weather conditions, etc.

Multi-Disciplinary Accident Investigation Data

Both authors were members of a multi-disciplinary accident investigation team (MDAI) at the University of Utah sponsored by NHTSA of the US Department of Transportation. Specialized expertise was available in several disciplines to conduct in-depth investigations including data collection and analysis for the pre-crash, crash and post-crash phases, as well as case accident reconstruction. All data were collected and analyzed by following the safety (Haddon) matrix format.

The program was initiated in 1968 in an attempt to collect in-depth accident data required for statistical data analysis. Only serious accidents involving late model passenger vehicles were investigated resulting in approximately 50 crashes investigated per team annually. The MDAI teams operated under the sponsorship of the US-and Canadian Departments of Transportations, as well as the Motor Vehicle Manufacturers Associations. The immediate objectives were the evaluation of the pre-crash, crash, and post-crash events collected according to the Haddon matrix. The data were collected and analyzed in case reports including accident reconstruction results and stored in computers at the University of Michigan. The MDAI data collected were approximately 90% of the data presently collected by NASS. The coding and format of the variables were based on the "Collision Performance and Injury Report", also known as the GM (General Motors) Form.

Although approximately 10,000 crashes were investigated until 1977 by nearly 20 teams operating in the US and Canada, certain accident data based statistical questions such as car size comparison, ABS performance, etc. could not be answered due to the limited number of particular vehicle models involved. During the last years (1976 – 1977) the emphasis was changed to more specialized studies including seat belt usage and a national sampling system.

Braking Accident Causation

In earlier editions of *Motor Vehicle Accident Reconstruction and Cause Analysis* certain MDAI-data-based accident statistics were published which are briefly reviewed below. Although we could analyze the data base to show certain general statistical trends and patterns, we could not provide information with any statistical significance, that would reveal, for example, how a specific design change made to a particular vehicle make and model yielded improved safety.

A careful computer generated data analysis of all MDAI cases and data interpretation by the Utah MDAI team had shown that in approximately two percent of these accidents investigators noted brake malfunction as contributing to accident causation. In several cases the investigating officer noted “loss of brake pedal” and no detailed follow-up investigation was carried out. Nearly all cases with brake malfunctioning involved faulty brake maintenance or lack of driver concern for safe brakes. A detailed review of the individual brake malfunctioning cases revealed that in approximately 89% of the braking accidents the investigator noted brake system failure as the primary accident cause. In approximately 25% of these cases information concerning brake failure was based on driver or police statements and no in-depth vehicle examination was carried out to verify accident causation. Vehicle instability due to brake lockup was noted in 11 % of the cases as primary accident cause. The important finding revealed that of the 64% cases verified as brake failure, all were due to faulty brake system maintenance or driver attitudes toward proper vehicle inspection. The highest failure rate was associated with wheel cylinder leakage (28%), followed by master cylinder leakage (10%), loose vacuum hose (7%), broken brake lines (7%), and others such as wet brakes, excessive drum wear and improper adjustment. In 24% of all braking cases worn brake pads or brake linings were noted as either primary or secondary accident cause.

We suspect that these statistical data relative to accident causation due to improper brake maintenance have not changed significantly over the years and may actually increase due to increased brake system complexity and economic pressures to reduce production costs. For example, in 2003 13 of 18 failures of Mercedes cars involved electronic systems. However, we expect that loss of vehicle directional stability due to premature rear brake lockup (11% of all braking cases in the late 1970’s) is practically eliminated due to virtually 100% use of four-wheel ABS and ECS systems. Proper maintenance is required since many modern brake system designs are rear-brake biased without functioning electronics.

Braking and Steering Accident Avoidance

The accident avoidance analysis discussed in Chapter 31, Steering to Avoid Collision, was applied to approximately 1000 MDAI cases. Since the data required for the avoidance analysis were not stored in the computer files, each case report was reviewed and relevant data retried. The results showed that in the late 1970’s (practically no US vehicles were equipped with ABS brakes) between 19 and 20% of the drivers involved in a collision attempted to brake, 9% to steer, and slightly less than 6% to brake and steer. All percentage figures tended to decrease as vehicle speed increased. Furthermore, we found that in the case of a straight road for the drivers that provided a control input approximately 80% attempted to brake, as compared with only 12% when traveling on a curved road.

The results revealed that only approximately 4% of all accident types could be avoided by increased brake system effectiveness (locking of brakes). Approximately 14% of intersection accidents and over 45% of all accident types could be avoided if all vehicles were equipped with ABS brakes. The readers must understand that these results are based upon drivers who apply their brakes and/or turn the steering wheel within a normal reaction time of not more than 1.5 seconds. It was further assumed that drivers would operate their vehicles below yet close to the limit of tire traction available.

Accident data collected by the German Mercedes Benz crash investigating team in the early 80's involving identical vehicle models equipped with and without ABS brakes showed 6 to 10% fewer accidents for their ABS-equipped cars. US-DOT studies showed that single-vehicle rollover accidents increased for ABS equipped cars, apparently indicating higher risk-taking by drivers.

This brief review of the older MDAI accident data collection system demonstrates that simple questions can probably be answered by individuals having a background in statistical analysis. More complex accident situations require an individual who is trained in accident reconstruction, automotive systems, and accident avoidance. Basically, when one is not certain that the basic data retrieved are correct and reliable, then any statistical data analysis and presentation is meaningless no matter how extensive the computer manipulations are. Surviving a Daubert challenge may be impossible.

Governmental Accident Data

NHTSA, the Insurance Institute for Highway Safety (IIHS), automotive manufacturers, Legal communities, research organizations, state governments, and others use accident data bases such as the National Automotive Sampling System (NASS), the Fatal Accident Reporting System (FARS), General Estimates System (GES), Crashworthiness Data Systems (CDS), and others. Other organizations maintain their own databases such as the University of Michigan Transportation Research Institute (UMTRI), as well as many vehicle manufacturers involving their vehicles.

NASS and FARS are the most widely used bases due the government's responsibility for their administration. Both government and private researchers have used the statistical results with far reaching effects causing changes in vehicle design, development of federal safety standards, and assisting juries in rendering verdicts based on objective accident related data. For example, FARS was used to evaluate crashes involving the side-mounted fuel tanks on GM pickup trucks, fires and resulting fatalities.

Likewise, NHTSA used these data bases to predict that fatalities in single-vehicle rollovers of SUVs will be reduced by over 67% (fatalities by 30%) if all SUVs were equipped with electronic stability controls. Federal German accident statistics revealed that Mercedes cars having electronic stability controls as standard equipment since 1999 resulted in 15% less crashes when compared to earlier models. In addition, the number of fatalities and severely injured occupants decreased from15 to five percent.

These brief comparisons reveal that traffic accident data bases and associated statistics and their interpretation must always be treated with care and sufficient skill levels to ensure that accurate conclusions and opinions are reached.

FARS – Fatal Accident Reporting System

In 1972 NHTSA began an accident data collection system involving key information on fatal crashes occurring in the US. The basic data come from the Police Accident

Report (PAR) with all states participating since 1975. The data and other supporting information are coded and entered in a governmental database by FARS analysts. FARS is a census, indicating that all qualifying accidents are included. The criteria is that a motor vehicle must be traveling on a highway customarily open to the motoring public, and result in an event causing at least one fatality of either an occupant or a non-motorist occurring within 30 days of the event (crash).

NASS – National Automotive Sampling System

NASS is random sample designed for statistical analysis meaning that each crash is representative of similar crashes that occur in the US. In-depth data are collected and analyzed. The crash is reconstructed using special computer-based programs. The final output is weighted (multiplied by an inflation or adjustment factor) to represent other similar crashes and becomes part of the data base. Currently, approximately 5,000 cases are entered annually. The information gathered by field investigators is based on the Haddon matrix and entered into a form. All related parameters are coded by NASS analysts. Administrative codes, calculations (Delta-V), weighting factors, quality controls, and others are entered as well.

NASS is constantly upgraded to include new parameters such as tire inflation pressure, tire tread depth, event data recorder (EDR) data, and others. NASS criteria are similar to the MDAI format, namely recent model year and at least one vehicle had to be towed from the crash site. Errors or mistakes with respect to NASS relate to any information entered incorrectly, unclear or confusing VIN data, type of accident and cause of death, point of impact versus damage area, vehicle damage coding (may not be the same in different states), and others.

Other data bases exist such as GES (General Estimates Systems) which contains less elements than FARS, and hence less detail, State Accident data bases (police reports), CIREN which is similar to MDAI with emphasis on injuries, CODES which is a limited data base with inputs from police, EMS and hospitals, and State Police Files which provide limited detail.

Computer Requirements to Access FARS or NASS

Special computer software is required to retrieve information from quantitative data bases. SAS is a computer software program for data analysis. The SAS system provides tools for information storage and retrieval, data modification and statistical analysis. Initial cost may be as high as $1800 with an annual licensing fee of $1500. Specific information can be obtained from the internet.

Technical Vehicle Inspection Data Bases

Several foreign countries have federal requirements for periodic safety inspections, often involving stringent standards including braking or steering performance. The

German Technical Inspection Association (TUV) conducted more than 7.6 million major vehicle inspections for a large number different vehicle models with the results published in the latest 2005 TUV Auto- Report. The report provides detailed statistical data on all safety related maintenance subjects for practically all manufacturers and their models sold in Germany. The report is published annually by AUTO BILD.

One example will illustrate how the TUEV Report can be utilized to strengthen a particular case involving brakes. A foreign manufacturer importing a particular model to both Germany and the US was sued in a class action for excessive front brake pad and rotor wear along with steering wheel vibrations and brake pedal oscillations resulting from front brake disc thickness variations (DTV). When the TUEV Report was quarried for the same model years, the following information, among other data, was found: “The brake rotors quickly become warped, and besides steering wheel oscillations the entire front end shakes (when braking) from higher speeds.”

More information can be obtained from the Auto Bild website at www.autobild.de.

Actual Case Examples

General Considerations

When FARS or NASS data bases are used with the intention to strengthen a particular aspect of a case, the limits of what can be obtained must be clearly understood. For this reason it is advisable to retain the services of a qualified accident data retrieval and analysis expert who will guide the attorney through the frequently confusing maze of minute details and dead ends. Hopefully, this aspect of the data analysis becomes patently clear when the applications of FARS and NASS are discussed in the sections that follow.

Case 1: Vehicle-Pedestrian Night-Time Accident

The case involves an SUV striking an elderly 75-year old pedestrian after dark at approximately 11 pm injuring her fatally. The pedestrian crossed a highway near an unmarked unlighted T-intersection. She and her husband had just left a Christmas party. She carried a bag filled with food. Her husband followed approximately 10 feet behind. The intersection was dark with some Christmas lights illuminated approximately 20 feet from the edge of the road. The pedestrian passed from the left to the right in front of the approaching SUV. The critical aspect of the case was that the driver of the SUV had consumed two beers resulting in a BAC of approximately 0.05. The defense attorney wanted to know what information FARS could provide to better understand other influence factors.

General accident statistics show that approximately 5300 pedestrians are killed in the US each year in traffic accidents. In terms of time, the peak of fatal accidents occurs between 7 and 8 pm. Approximately 30 to 40% of the fatally injured pedestrians older than 15 years had been drinking. A detailed data analysis of FARS revealed the accident statistics as illustrated in Table 1 and Table 2. Table 1 applies to crossing at an intersection, while Table 2 applies crossing at a non-intersection. Only the first data columns are different in each of the figures. The data shown summarize the average risk of fatal injury based on the last five years of FARS (1997 – 2001). The FARS researcher tried to duplicate the conditions existing at the time of the accident with respect to the actions and characteristics of the pedestrian.

Variable> Year	Age(75+) Intersection	9-11:59PM (M-F)	Light Trucks	Walking in Roadway	Improper Crossing	Failed to Yield ROW	Not Visible	Inattentive (talking, eating,etc.)	Physical Impairement
1997	34.3	16.4	34.6	29.3	29	14.9	6.9	3.2	1.5
1998	35.3	16	36.4	30.5	29.3	13.6	8	2.5	1.4
1999	35.8	17.5	36.5	28.9	30.3	13.6	8.1	2.1	1.7
2000	34.7	16.4	37.4	25.5	29.7	14.3	9.7	2.6	1.7
2001	38.4	17.4	38.1	26	28	14.2	9.4	3	1.3
1997-2001	**35.7**	**16.74**	**36.6**	**28.04**	**29.26**	**14.12**	**8.42**	**2.68**	**1.52**
	0.357	0.1674	0.366	0.2804	0.2926	0.1412	0.0842	0.0268	0.0152

This Table summarizes the average Risk of Fatality based on the last Five years of FARS. (1967-2001)
The table attempts to duplicate the conditions in which the accident occurred.
The pedestrian is 75-year-old+. The above shows the corresponding percentages.
Intersection: 35.7% probability. The pedestrian was crossing a T-intersection, walking on the roadway.
Time of Day: 16.7% probability at 9-11:59PM. The highest rate of pedestrian fatalities occurs between 6-9:59PM.
Light Trucks: 36.6% probability of being impacted by a Light Truck, second only to Passenger Cars.
Walking in Roadway:28% probability, if pedestrian was walking in the roadway, as opposed to walking on the sidewalk.
Improper Crossing: 29.3% probability, if pedestrian intended to cross roadway but did it improperly. Includes jaywalking.
Failed to Yield Right of Way: 14.2% probability if pedestrian didn't wait for vehicle to continue or stop.
Not visible: 8.4% probability. Obscured by obstacles or wearing dark clothing.
Inattentive: 2.7% probability. Talkin, eating, etc.
Physical impairment: 1.5% probability. Paraplegic, etc. Includes hearing impaired or deaf.
These probabilities represent high percentages compared to other ages.
These probabilities cannot be added unless they occur independently.
A conclusion would be that this pedestrian did many things wrong, or high risk, independent of what the driver of the vehicle did.

Table 1 for Case 1: Car/Pedestrian Accident at Intersection

Variable> Year	Age (75+) Non Intersection	9-11:59PM (M-F)	9-11:59PM (F-Sun)	Light Trucks	Walking in Roadway	Improper Crossing	Failed to Yield ROW	Not Visible	Inattentive (talking, eating,etc.)	Physical Impairement	
1997	65.4	16.4	26.1	34.6	29.3	29	14.9	6.9	3.2	1.5	
1998	64.6	16	28.5	36.4	30.5	29.3	13.6	8	2.5	1.4	
1999	64.2	17.5	27.1	36.5	28.9	30.3	13.6	8.1	2.1	1.7	
2000	65.2	16.4	26.5	37.4	25.5	29.7	14.3	9.7	2.6	1.7	
2001	61.6	17.4	26.4	38.1	26	28	14.2	9.4	3	1.3	
1997-2001	**64.2**	**16.74**	**26.92**	**36.6**	**28.04**	**29.26**	**14.12**	**8.42**	**2.68**	**1.52**	**Additive Property**
	0.642	0.1674	0.2692	0.366	0.2804	0.2926	0.1412	0.0842	0.0268	0.0152	

This Table summarizes the average Risk of Fatality based on the last Five years of FARS. (1967-2001) NonIntersection is included.
The table attempts to duplicate the conditions in which the accident occurred.
The pedestrian is 75-year-old+. The above shows the corresponding percentages.
NonIntersection: 64.2% probability. The pedestrian was crossing a T-intersection, walking on the roadway, not in the crosswalk, if ava
Time of Day: 16.7% probability at 9-11:59PM. The highest rate of pedestrian fatalities occurs between 6-9:59PM.
Light Trucks: 36.6% probability of being impacted by a Light Truck, second only to Passenger Cars.
Walking in Roadway:28% probability, if pedestrian was walking in the roadway, as opposed to walking on the sidewalk.
Improper Crossing: 29.3% probability, if pedestrian intended to cross roadway but did it improperly. Includes jaywalking.
Failed to Yield Right of Way: 14.2% probability if pedestrian didn't wait for vehicle to continue or stop.
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Inattentive: 2.7% probability. Talkin, eating, etc.
Physical impairment: 1.5% probability. Paraplegic, etc. Includes hearing impaired or deaf.
These probabilities represent high percentages compared to other ages.
These probabilities cannot be added unless they occur independently.
A conclusion would be that this pedestrian did many things wrong, or high risk, independent of what the driver of the vehicle did.

Table 2 for Case 1: Car/Pedestrian Accident at Non-intersection

Inspection of both tables reveals that an elderly pedestrian (75 years or older) has a 64.2% probability of being killed (FARS collects fatalities only) by a car when crossing at a non-intersection as compared with 35.7% when crossing at an intersection. Additionally, crossing at 9 to 12 pm on a weekend shows a 27% probability of being killed regardless of age. Finally, improper crossing has a 29% probability of being killed regardless of age or time of day. More details can be seen for different variables indicated.

An even more detailed analysis can be done that would show how many elderly pedestrians are killed in the weekend group in a 24-hour day, and when related to the non-intersection elderly pedestrian group, yields a probability exceeding 64.2%, say 68% (not very many elderly people are expected to be walking the streets around midnight).

What is the overall conclusion to be drawn in this case based upon the objective FARS data shown? The probability of being killed as an elderly pedestrian crossing an unlighted highway at a non-intersection around midnight during the weekend is approximately 68%.

Tables 1 and 2 represent very rough raw data, however detailed enough for attorney and expert to understand the problems at hand and to formulate specific opinions and exhibits to be presented to the jury.

Case 2: Plymouth Voyager Combined Braking and Steering to Avoid Accident

The fatal accident occurred in German on the autobahn. The road was wet. A crash caused a traffic jam with all traffic stopped. The driver of a 1999 Plymouth Voyager approached the vehicles in front not realizing quickly enough that they were stopped. His last words were: “I can’t stop.” He steered to the right, avoiding the stopped traffic only to crash into a guardrail, slid along the guardrail and then collided with the trailer of a stopped tractor-trailer combination. The driver’s side A-pillar area smashed into the right rear corner of the trailer killing the driver.

Careful inspection of the automobile revealed no defects of the hydraulic brake system. The steering system likewise was in good mechanical condition. The vehicle was not equipped with ABS brakes. However, ABS brakes were offered by Chrysler as optional equipment.

The basic question was whether ABS brakes would have made any difference in the outcome of this accident? And if so, why were ABS brakes not offered as standard equipment rather than letting the somewhat uniformed motoring public make this safety critical decision? This reasoning appears to be a logical argument. However, a very important point to consider is the following. Since the driver was able to quickly steer around stopped traffic to the right and back to the left before impacting the guardrail with the right front corner, the front brakes of the Voyager were not locked, indicating that the driver either was not braking or applied a pedal force that was insufficient to lock the front brakes. At this point of case preparation the expert should perform a brake system design analysis resulting in a braking performance diagram similar to Example 24-3 of the 7th edition of Motor Vehicle Accident Reconstruction and Cause Analysis. Accident reconstruction software MARC 1, Module V, Braking System Design Analysis can be used to efficiently conduct this analysis, yielding both numerical results and the braking performance diagram. Inspection of the results would indicate whether or not a maximum pedal force application in the case of ABS brakes produces a vehicle deceleration sufficiently high to avoid or successfully mitigate the accident, as compared to a brakes-not-locked pedal force and accompanying lower vehicle deceleration (no ABS brakes) resulting in the accident under consideration. MARC 1 download can be obtained at the internet at www.pcbrakeinc.com.

The expert must also perform an accident avoidance analysis with respect to the stopped traffic by use of the Steering to Avoid Collision analysis discussed in Chapter 31. Based upon the lateral swerving maneuver that the driver was able to accomplish and the lateral acceleration (wet road), how far back was the Voyager when the driver began to react and to steer. Is this distance sufficient to make a difference when ABS brakes are used instead of standard brakes?

NASS was accessed with the qualification to look for 1995-2001 Plymouth Voyagers with and without ABS brakes that were involved in accidents where the critical pre-crash event was a stopped vehicle in the lane, both on wet and all road surfaces.

The lengthy and somewhat confusing first-cut raw data output is presented in Table Case 2. The numerical codes in NASS identify the following brake system equipment:

1. ABS not available
2. Four-wheel ABS, standard
3. Rear ABS-only, standard
4. ABS standard, wheels unknown
5. Four-wheel ABS, optional
6. Rear ABS only, optional
7. ABS optional, wheels unknown
8. (Not used)
9. Unknown

The following rough data output are the first results obtained from the NASS search.

Make these tables look prettier or leave them like this????

All vehicles equipped with ABS in NASS 1995-2001.

ANTILOCK BRAKES				
ANTILOCK	Frequency	Percent	Cumulative Frequency	Cumulative Percent
NO ABS	8696125	33.24	8696125	33.24
2	4830734	18.46	13526859	51.70
3	1838434	7.03	15365293	58.73
4	852036.5	3.26	16217329	61.98
5	4297183	16.42	20514512	78.41
6	126776.1	0.48	20641288	78.89
7	2206837	8.43	22848125	87.33
8	8387.149	0.03	22856512	87.36
9	3307178	12.64	26163690	100.00

All Plymouth Voyagers equipped with ABS in NASS 1995-2001.

ANTILOCK BRAKES				
ANTILOCK	Frequency	Percent	Cumulative Frequency	Cumulative Percent
1	8650.247	16.05	8650.247	16.05
2	1508.394	2.80	10158.64	18.85
5	9576.331	17.77	19734.97	36.63
7	2333.78	4.33	22068.75	40.96
9	31810.67	59.04	53879.42	100.00

ABS on all vehicles involved in accidents where Critical PreCrash Event is a vehicle Stopped in Lane. (preevent=50). All surfaces.

ANTILOCK BRAKES				
ANTILOCK	Frequency	Percent	Cumulative Frequency	Cumulative Percent
1	742321.8	35.43	742321.8	35.43
2	314998.8	15.03	1057321	50.46
3	171708.1	8.19	1229029	58.66
4	57767.12	2.76	1286796	61.41
5	325071.4	15.51	1611867	76.93
6	13595.48	0.65	1625463	77.58
7	173679.4	8.29	1799142	85.87
9	296153.2	14.13	2095295	100.00

Frequency Missing = 504296.08258

ABS on all Plymouth Voyagers involved in accidents where Critical PreCrash Event is a vehicle Stopped in Lane. (preevent=50). All surfaces.

ANTILOCK BRAKES				
ANTILOCK	Frequency	Percent	Cumulative Frequency	Cumulative Percent
1	51.31773	0.50	51.31773	0.50
2	297.386	2.90	348.7037	3.40
9	9919.595	96.60	10268.3	100.00

ABS on all vehicles involved in accidents of WET surfaces (surcond=3)

ANTILOCK BRAKES				
ANTILOCK	Frequency	Percent	Cumulative Frequency	Cumulative Percent
1	236492	34.59	236492	34.59
2	144887.6	21.19	381379.6	55.78
3	39404.01	5.76	420783.6	61.54
4	14452.6	2.11	435236.2	63.65
5	114170.2	16.70	549406.4	80.35
6	427.214	0.06	549833.6	80.42
7	40705.93	5.95	590539.5	86.37
9	93205.48	13.63	683745	100.00

ABS on Plymouth Voyagers involved in accidents of WET surfaces (surcond=3)

ANTILOCK BRAKES				
ANTILOCK	Frequency	Percent	Cumulative Frequency	Cumulative Percent
1	1262.66	84.76	1262.66	84.76
2	72.50019	4.87	1335.16	89.62
9	154.561	10.38	1489.721	100.00

ABS on Plymouth Voyagers involved in accidents of WET surfaces (surcond=3)
Maneuver*Antilock

ABS on all vehicles involved in accidents where Critical PreCrash Event is a vehicle Stopped in Lane. (preevent=50). Wet surfaces. (surcond=3).

ANTILOCK BRAKES				
ANTILOCK	Frequency	Percent	Cumulative Frequency	Cumulative Percent
1	2060.181	19.40	2060.181	19.40
2	1709.562	16.10	3769.744	35.49
4	1095.128	10.31	4864.871	45.80
5	4442.516	41.83	9307.388	87.63
7	7.296133	0.07	9314.684	87.70
9	1306.703	12.30	10621.39	100.00

ABS on Plymouth Voyagers involved in accidents where Critical PreCrash Event is a vehicle Stopped in Lane. (preevent=50). Wet surfaces. (surcond=3).
NONE.

Table Case 2: Plymouth Voyager Accident/NASS Data Analysis

Inspection of the first table indicates the following for the 1995 through 2001 model years for ALL vehicles (not just Plymouth Voyagers): 33.24% had no ABS (standard brakes), 18.46% had ABS brakes as standard equipment, 7.03% rear ABS as standard, 3.26% ABS standard but the ABS configuration was unknown, 16.42% had four-wheel ABS optional, 0.48% rear ABS optional, 8.43% ABS optional but ABS configuration unknown, and 12.64% unknown.

At this point the expert may be able to eliminate certain options. For example, was the Plymouth Voyager ever produced with rear ABS only, either as standard or optional equipment during the 1995 to 2001 model years? The following table will answer the question.

The table showing all Plymouth Voyagers equipped either with or without ABS brakes indicates the following: 16.05% standard brakes (no ABS), 2.08% four-wheel ABS, 17.77% four-wheel ABS optional, and 4.33% ABS with configuration unknown (should be 4-wheel ABS since rear-only ABS was never installed), and a large number 59.04%, unknown.

A comparison indicates that when all vehicles are considered only 16% of 1995to 2001 Voyagers sold had non-ABS brakes versus 33% of all vehicles.

The remaining data tables attempt to show different accident scenarios (critical pre-crash event is a stopped vehicle in the road, all accidents regardless of crash configuration, and then for either all road surfaces (ice to dry), and wet roads, and again, comparing ALL vehicles with the Voyager.

Only codes 1 and 2 need to be considered. For ALL vehicles involved in accidents with a stopped vehicle on all surfaces, the following exists: 35.43% non-ABS, 15.03% ABS. The table showing Plymouth Voyagers only, yields: 0.50% non-ABS and 2.90% ABS.

For wet roads and all accidents the results are, for ALL vehicles: 34.59% non-ABS versus 21.19% ABS brakes, and for Voyagers only: 84.76% non-ABS, 4.87% ABS brakes.

The table showing the data for ALL vehicles for wet roads and a vehicle stopped in the lane: 19.40% non-ABS, and 16.10% ABS brakes. The data also indicated that there were no ABS-brakes equipped Plymouth Voyagers involved in an accident occurring on a wet road with another vehicle stopped in its lane (NONE).

While the NASS data analysis shows that there are 84.76% non-ABS Voyagers versus only 4.87% ABS Voyagers involved in all accidents on wet roads, none involved a stopped vehicle ahead. This finding might be of interest when the evidence clearly indicates that the driver applied the brakes. It would be interesting to determine why there are such a large number of non-ABS Voyagers on wet roads compared with their ABS counter parts. Further NASS research may reveal that wet roads play a significant role by making it more likely that drivers lock their brakes more frequently, and that moisture may affects brake torque balance front-to-rear.

The basic NASS data conclusion is that there is a high probability that ABS brakes would not have made a significant difference in this particular case. As mentioned earlier, the most difficult issues existing in this case are related to driver pedal force application (no front brakes locked in the accident), and if he had applied the brakes, would ABS brakes make a difference in view of the reduced friction (wet roads) and short distance to the stop the vehicle or lower the impact speed to mitigate injuries? What deceleration did the driver utilize with a reduced pedal force versus what maximum deceleration could he utilize with a full pedal application and ABS modulation.

Case 3: Combined Braking/Steering Data Analysis After a Design Change

The statistical analysis for this case shows how a design change may cause a significant over involvement in certain handling maneuvers.

In general, Diesel engine pickup trucks equipped with hydraulic brakes use a hydro-boost braking system to provide power brakes to the driver. In the hydro-boost system a single hydraulic pump is used to provide the boost energy for both the brakes and power steering system. In some designs when the driver carries out a combined braking and steering maneuver the steering system loses its assist effectiveness. Stated differently, the brakes when applied with a certain pedal force level use all or nearly all of the pump pressure, depending upon the specific pedal forces involved.

The NASS data were accessed with the qualifications of only looking certain trucks in terms of manufacturer, model years, Diesel or gasoline engine (gasoline engines use a standard vacuum booster utilizing engine vacuum for power brakes rather than the steering pump), and which of the two engine, and hence, brake design versions had higher involvement in accidents when a combined braking and steering maneuver was attempted prior to the accident. The results are shown in the figure below in form of a bar chart. Inspection reveals that when a combined braking-right turn maneuver was attempted to avoid the crash, 85.1% were Diesel engine trucks compared to 14.9% gasoline trucks. For combined braking-left turn maneuver the percentage numbers were 38.9 and 61.1%, respectively. When both steering directions are combined, the trucks using a hydro-boost brake system (Diesel engine) are approximately 63% more involved in combined braking-steering maneuvers than their vacuum-brakes (gasoline engine) counter parts.

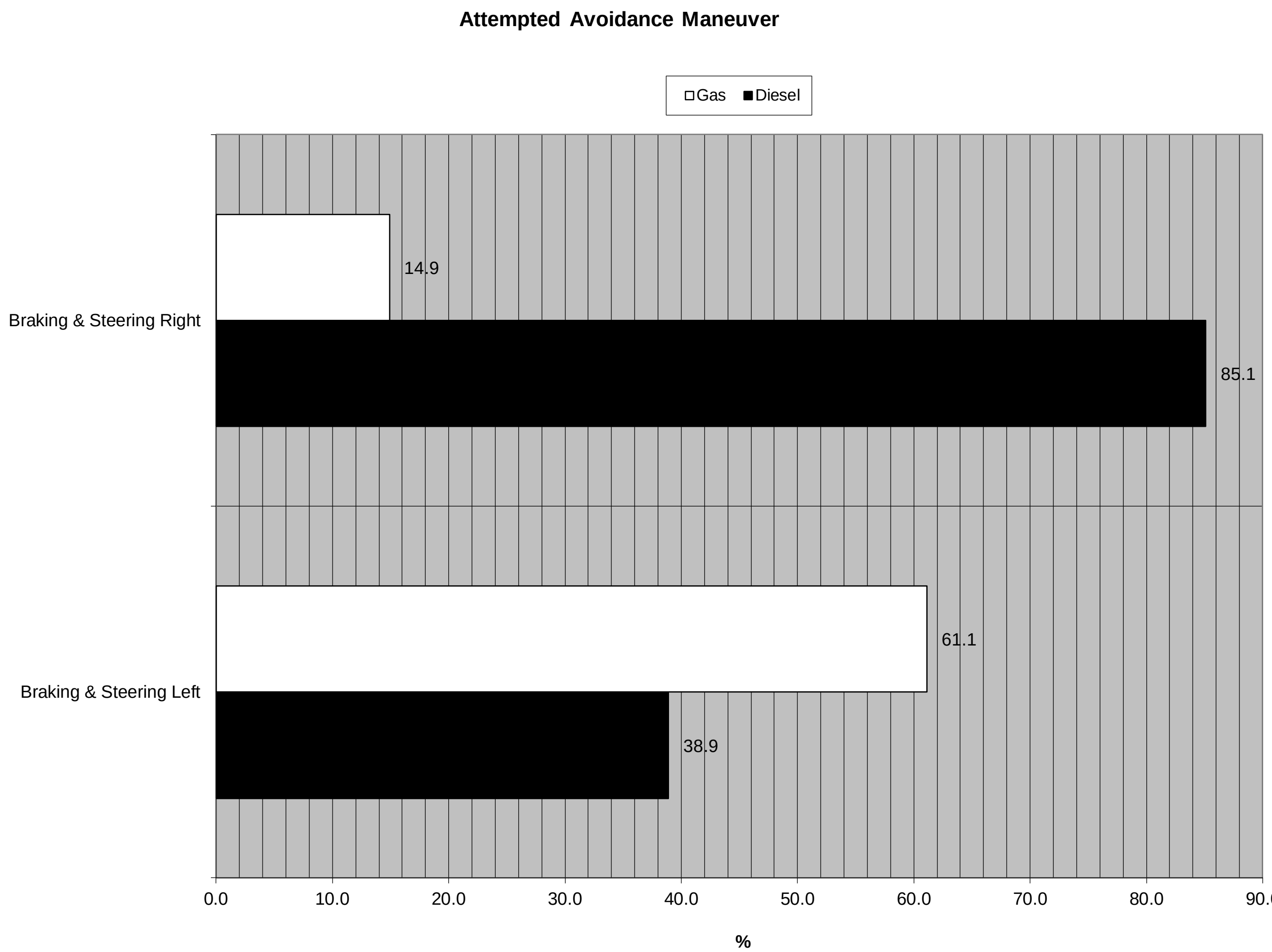


Figure for Case 3: Combined Braking/Steering Data Analysis

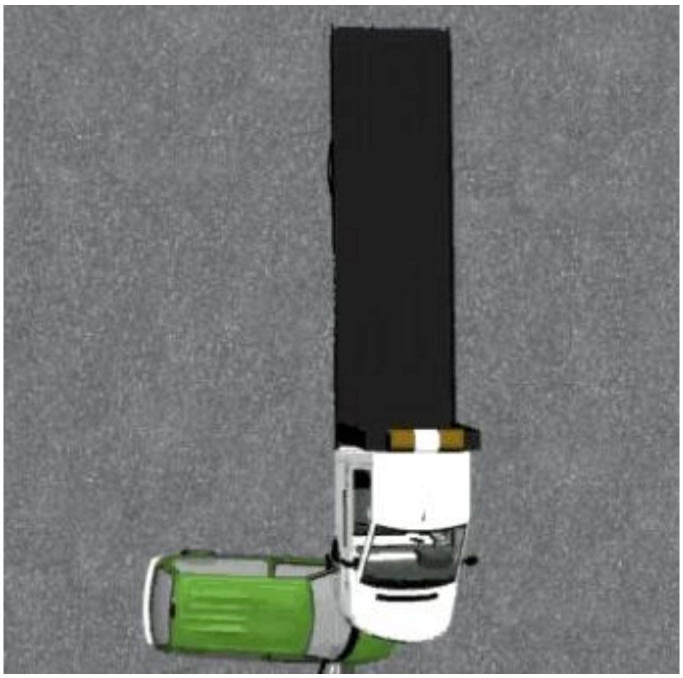
No attempts have been made to ascertain what factors determine the nearly six fold involvement of Diesel trucks in right turns compared to a less than equal involvement in left turns.

Case 4: Extensive MARC1 and NASS/FARS Analysis for Injury Causation/Severity Assessment

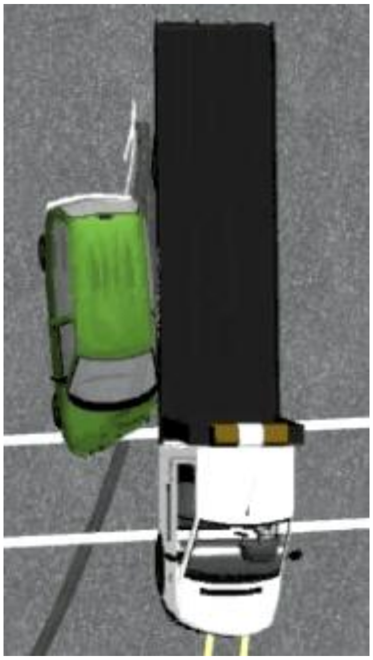
Case Summary:

A Mazda MPV van started forward when the light turned green. A tow truck was trying to beat the light and hit the van at approximately 50 mph...

First impact: The right front corner of the tow truck hit the left front portion of the van.



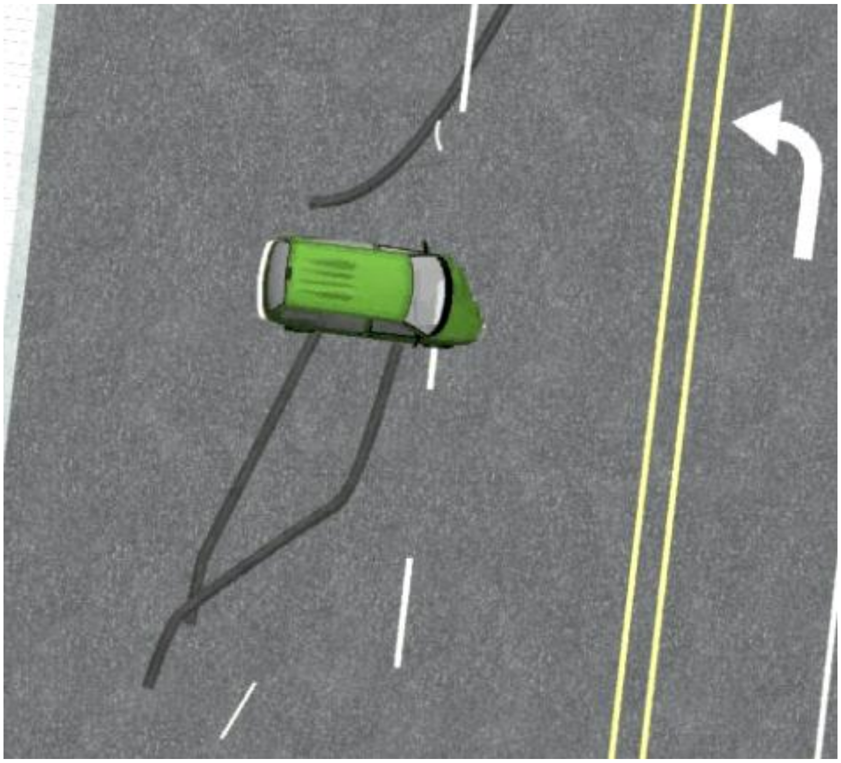
Second impact: The tow truck and the van slapped together.

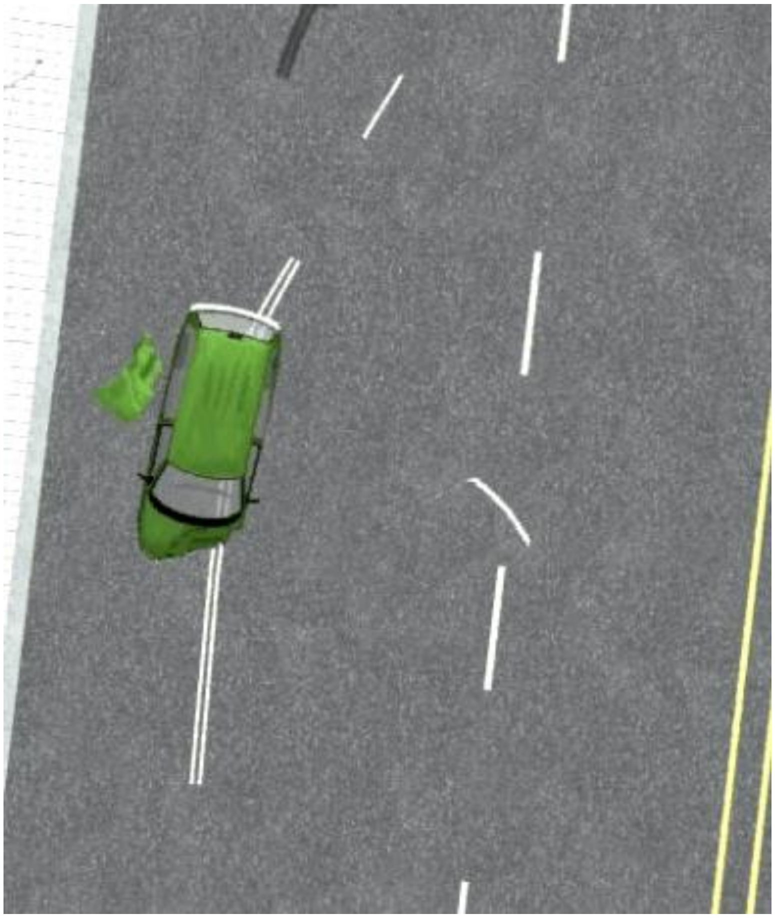


Third impact: The tow truck impelled the van to its right and continued forward.

Fourth impact: The van lost its left front wheel and moved to its right at approximately 40 mph.

Fifth impact: The van rotated clockwise and came to rest facing forward.





The two unbelted occupants of the van sustained injuries corresponding to the impacts with the tow truck.

One of the occupants was found on the driver's seat. The other was found lying down by the curb.

The critical questions were:

Who was the driver?

Was the occupant found outside the van ejected?

If so, how, when, and where was the ejection path?

Were the injuries sustained by the unbelted occupants significantly different had they been belted?

Accident reconstruction using MARC1, concurring with a witness statement, determined that the ejection of any occupant would have been impossible at any moment in the series of events of this accident.

It also was determined that the person found outside of the van had indeed been the driver, while the person found on the driver's seat had been the right front seat passenger. This person exited on his own through the right door of the van.

The opposing expert suggested that it was the right front passenger who had been ejected either through the driver's window or through the rear backlight when the rear of the van contacted the curb. MARC1 helped demonstrate that the first scenario was impossible because this occurred in the first impact when both vehicles were past the center of the intersection and the occupant was found further down the road. Additionally, the deployed air bag and the body of the driver would have prevented any ejection. The second scenario was also proven to be impossible using an animation and placing a van drawn to scale and moving it along the marks, scuffs and gouges left by it. It showed that the rear of the van never contacted the curb.

Analysis of the NASS databases for a similar crash configuration and type of impacts showed the following:

The injuries are consistent with the seat position of the occupants and their kinematics in response to the impacts, whether they were belted or unbelted. In order to make the proper comparison, the injuries received by these occupants had to be coded using the Abbreviated Injury Scale (AIS) and have them correspond with the similar Collision Damage Classification (CDC).

In regards to significance, the analysis of the database showed that the collisions were so severe that it would have not mattered if the occupants had been belted or unbelted. Expert biomedical publications confirm this. The main reason is that in severe collisions the seat belts can become sources of injury.

NASS 1991-2002 (National Automotive Sampling Systems, File-Years 1991 through 2002) All Minivans Similar to Mazda MPV Impacted on the Left Side Drivers Lap and Shoulder Belted Injury Source for all Injury Records		
Injury Source	%	Frequency
Left B-Pillar	15	16,120
Left Side Interior	13	13,522
Belt Webbing/Buckle	12	12,840
Other non-contact (i.e., Fire, gas, liquid)	8	8,469
Air Bag, Driver Side	5	4,990
Left Side Hardware/Armrest	3	2,788
Flying Glass	2	2,164
Unknown	2	1,883
Left A-Pillar	1	1,197
Left Side Window Glass/Frame	1	632
Total for all records		106,216

NASS 1991-2002 (National Automotive Sampling Systems, File-Years 1991 through 2002) All Minivans Similar to Mazda MPV Impacted on the Left Side Right Front Occupants Lap and Shoulder Belted Injury Source for all Injury Records		
Injury Source	%	Frequency
Belt Webbing/buckles	20.6	3,831
Right side interior	13.0	2,420
Center IP	12.6	2,349
Right IP	12.5	2,316
Air Bag - Pass. Side	9.6	1,783
Seat back support	8.9	1,646
Other non contact	5.8	1,087
Flying glass	4.3	802
Right side window glass/frame	3.0	552
Injured, unk. Source	2.5	458
Transmission lever floor/console	2.3	427
Mirror	1.0	178
Right B-pillar	1.0	178
Other interior object	0.9	168
Glove comp. door	0.6	117
Other occupants	0.6	113

Total 18,593

NASS 1991-2002 (National Automotive Sampling Systems, File-Years 1991 through 2002) All Minivans Similar to Mazda MPV Impacted on the Left Side Drivers Lap and Shoulder Belted Body Region Affected		
Body Region	%	Frequency
Upper limbs (Extremity)	19.7	20,919
Lower limbs (Extremity)	16.4	17,464
Head	14.0	14,880
Back	11.6	12,327
Neck / Spine	9.5	10,070
Chest	9.2	9,728
Face	4.6	4,886
Unknown	4.2	4,484
Wrist / Hand	3.0	3,236
Shoulder	2.5	2,641
Ankle / Foot	2.1	2,278
Abdomen	1.8	1,928
Thigh	0.7	701
Forearm	0.3	312
Knee	0.2	207
Leg	0.1	68
Arm (Upper)	0.0	46
Pelvis	0.0	42

Total records 106,217

NASS 1991-2002 (National Automotive Sampling Systems, File-Years 1991 through 2002) All Minivans Similar to Mazda MPV Impacted on the Left Side Right Front Occupants Lap and Shoulder Belted Body Region Affected		
Body Region	%	Frequency
Lower limb (extremity)	27.3	5,206
Face	20.5	3,904
Upper limb (extremity)	17.1	3,266
Neck / Spine	9.6	1,840
Chest	6.9	1,310
Back	4.5	863
Abdomen	4.0	764
Head	3.4	652
Wrist / Hand	3.1	599
Unknown	2.4	458
Forearm	0.5	100
Pelvis (hip)	0.4	74
Shoulder	0.3	48

Total		19,084

NASS 1991-2002 (National Automotive Sampling Systems, File-Years 1991 through 2002) All Minivans Similar to Mazda MPV Impacted on the Left Side Drivers Lap and Shoulder Belted Injury Lesion for all Injury Records		
Lesion	%	Frequency
Contusion	57	60,707
Laceration	13	13,505
Abrasion	11	11,779
Strain	8	8,469
Sprain	4	4,418
Fracture	3	3,102
Concussion	1.0	1,098
Dislocation	0.5	581
Unknown	0.1	135
Avulsion	0.01	8
Total for all records		106,216

NASS 1991-2002 (National Automotive Sampling Systems, File-Years 1991 through 2002) All Minivans Similar to Mazda MPV Impacted on the Left Side Right Front Occupants Lap and Shoulder Belted Injury Lesion for all Injury Records		
Lesion	%	Frequency
Contusion	42	7,951
Abrasion	31	5,837
Strain	9	1,767
Fracture	7	1,337
Avulsion	6	1,197
Laceration	5	877
Dislocation	0.3	51
Unknown	0.2	45
Sprain	0.1	20
Total for all records		19,082

NASS 1991-2002 (National Automotive Sampling Systems, File-Years 1991 through 2002) Minivans Similar to Mazda MPV Impact to Left Front Quarter Panel Area Right Front Passengers Lap and Shoulder Belted Frequency (weighted)	
Total	1730
Mazda MPVs	245
Injured*	58*

(*) Notes:

Secondary damage to the Left Rear Quarter Panel Area (from slapping together).
Treatment: Hospitalized
Days hospitalized: 10
Police Injury Rating: Incapacitating (A)
Maximum AIS: 4 (Abbreviated Injury Scale: Severe)
Injury: Chest Fractures
Air Bags: Deployed (Frontal)

FARS 1991-2002 (Fatal Accident Reporting Systems, File-Years 1991 through 2002) Minivans Similar to Mazda MPV Clock Direction of Impact: 08, 09, or 10. Right Front Passengers Lap and Shoulder Belted Frequency			
Police Reported Injury	Mazda MPVs	All Minivans	
Not Injured (O)	5	66	
Possible (C)	3	31	
Non-Incapacitating (B)	5	54	
Incapacitating (A)	2	39	
Fatal (K)	0	24	
Total	15	214	

Notes:
There were NO complete Ejections reported.
One (1) Partial Ejection Reported. Unknown ejection path.

Statistical Data Analysis for Uncommon Accidents

Although the subject National Accident Databases conform to a specific set of criteria such as, severe injuries/fatalities, large damage, vehicles in transport, etc. it is possible to find data (direct or by inference) on unusual accidents or on accidents that do not conform to the preset criteria. Some examples would be:

- Injuries in low speed impacts, frontal, rear end, etc.
- Non traffic accidents: Backovers in driveways, non school buses acting as school buses, etc.
- Texting vs. Vehicle Tracking (Handling) vs. Road Crown, etc.

The following case illustrates an example of the above.

Case 5: Low Delta-V Injury Analysis of RV pulling a Trailer

A large RV was pulling a Trailer (19,000 to 25,000 lb) on a mountain road during a snow storm. A Ford F450 (15,000 lb) could not stop and its left side rear ended and sideswiped the right rear side of the Trailer. The driver of the RV stopped on the right side of the road. A large Dodge Van could not stop and rear-ended the Trailer in the right rear with its left front side.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The damage of the trailer shown in the accident scene photographs indicates that the Ford produced damage to the higher portions on the rear of the trailer, while the lower damage in the floor area appears to have been made by the Dodge van. The lower damage indicates a severe impact force.

The impact between the left side of the Ford F450 and cargo box and the right rear corner of the trailer/RV yielded an RV delta-V of approximately 10 to 12 mph when Ford weight is 13,240 lb, impact speed 50 mph; RV weight is 17,000 lb and 25 mph travel speed at impact. A coefficient of restitution between 0 and 0.2 was used. In the second impact with the Dodge the following crash details can be determined: delta-V = 10.45 mph when Dodge weight is 5000 lb, 40 mph impact speed and coefficient of restitution of 0.15. Captain Daugherty describes the impact with the Dodge as more severe than the Ford F-450.

The defense expert opined that the subject accidents were not of sufficient severity to have caused the injuries sustained by the driver of the RV. To determine if the defense expert's opinion is correct, we needed an answer to the following question:

"Do real collisions show actual specific injuries, such as to the wrist/hand, occurring as a result of rear impacts involving a velocity change or delta-V of approximately 8 to 12 mph?"

To determine the answer, the NASS CDS (National Accident Statistical System – Crash Worthiness Data System) data base was queried. Our analysis clearly showed that the defense expert was wrong and his opinion is not substantiated by objective data obtained from a database containing information on complete real-life injury caused by certain impacts.

The defense report only mentions the injury to the driver of the RV as coded in the Police Report. He quotes: "He was listed as injury code "0" (No Apparent Injury)."

The NASS data collection program contains the best information available in real-world crashes.

The NASS CDS data was queried to search for applicable injuries in similar delta-V ranges of approximately 10 mph and crash type as experienced by the Driver of the RV in the subject accident.

Even though NASS collects serious crashes with substantial injuries, the CDS files were queried to only determine if wrist/hand injuries, as a result of a moderate rear end impacts, would appear.

NASS was queried using the following six filters (the database contains records with all the variables recorded that permits the analyst to do specific searches):

1. 1991-2010 years.
2. All vehicles impacted in the rear.
3. At 5, 6, 7 o'clock PDOF (Principal Direction of Force) only.
4. Exhibiting damage in the form of deformation to the Extent of 1, per the CDC (Collision Deformation Classification protocol). The Extent of deformation of "1" represents the minimum amount of damage that can be considered.
5. DeltaV of less than 15 mph.
6. Only injuries to the arm, elbow, forearm, and/or wrist/hand.

Note: Injuries to the head, neck, or back were not queried. If they had been included, the number of injuries would be significantly larger.

Findings:

1. Total DeltaVs between 8 and 11.8 mph.
2. Longitudinal DeltaVs between 8 and 11.8 mph.
3. Lateral DeltaVs between 0 and 1.9 mph.
4. Maximum crush: 6 inches. (The exact measurements appear).
5. CDCs: 6BZEW1. (The code indicates the following: 06=PDOF at 6 o'clock, the rear of the vehicle. B=Back, general area of damage. Z= Right+Center, specific horizontal areas. E=Everything, specific vertical areas. W=Wide, Type of damage distribution (>18 in.). 1=Extent of damage (penetration).
6. MAIS=1. (Maximum Abbreviated Injury Scale (AIS) for these injuries. AIS=1 (Minor) includes the following lesions to the upper extremity: contusion, sprain, finger fracture, finger dislocation.
7. 3,531 injuries (sprains) to the wrist joint. This is national estimate frequency as determined by using the above filters.

The statistical data show that 3,531 wrist/arm injuries occurred.

Based upon the objective findings, the injuries sustained by Mr. L. could have occurred in the subject accidents. It is equally likely (the probability is the same) that the injuries could have been caused by the either the first or second impact.