Spring 2021

Side Impact Collisions: Trucks Versus Sedans

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April 2021

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List of Acronyms

ABS	Antilock Brakes
CISS	Crash Investigation Sampling System
CRSS	Crash Report Sampling System
FARS	Fatality Analysis Reporting System
FMVSS	Federal Motor Vehicle Safety Standard
GES	General Estimates System
LTV	Light Trucks and Vans
MDB	Moving Deformable Barrier
MPH	Miles Per Hour
MV	Multiple Vehicle
MY	Model Year
NASS	National Automotive Sampling System
NCSA	National Center for Statistics and Analysis
NHTSA	National Highway Traffic Safety Administration
RF	Right Front
RFP	Right Front Passenger
SCI	Special Crash Investigations
SID	Side Impact Dummy
SV	Single Vehicle
TTI	Thoracic Trauma Index
TTI(d)	Thoracic Trauma Index in Dummies

Section 1: Introduction

1.1 Executive Summary

This report serves as a literature review on the topic of collisions, specifically side impacts, on light trucks and passenger vehicles in the state of Ohio and nationally. The primary goal is determining the effects of safety standards on a sedan or truck when involved in a fatal side impact collision, or "T-bone" collision. A large focus of the report will be on Federal Motor Vehicle Safety Standard (FMVSS) 214 and its effect on fatalities of drivers and right front passengers (RFP) in light trucks and vans (LTV) and passenger cars. Reports from the National Highway Traffic Safety Administration (NHTSA) on various safety measures such as static and dynamic testing and side door beams are examined.

The NHTSA articles provide crash analysis data on a national scale between the 1980's and the early 2000's. These are used as the comparison for the current crash statistics for the state of Ohio from 2014 to 2018. Clear results of improvements are seen by comparing the sets of data and proper recommendations for further improvements are discussed at the end. Various factors affecting fatality risk are discussed, such as point of impact, type of vehicles involved, and vehicle age. Comparing the data from the 90's to the 2010's time periods allow for new trends and effects of this specific collision in Ohio and nationally to be determined.

All state of Ohio data comes from the National Highway Traffic Safety Administration's Fatality Analysis Reporting System (FARS) database. The latest fully completed data sets were from 2018. So, data spanning from 2014 to 2018 is the main focal point of comparison in this report. Only data related to side impact collisions for passenger cars and light trucks are evaluated. However, the discussed research is used to evaluate safety standards' effectiveness,

and thus includes data from all 50 states from the late 1980's, and 1990's when the standards were introduced.

1.2 Assumptions

For the purposes of this report, it should be assumed that the terms "sedan" and "passenger car" refer to any vehicle definition under Class. ID 1 (Figure 1). These terms will be used interchangeably throughout the report. It should be assumed that the term "truck" and "light truck" are referring to the same thing. Only light trucks will be discussed in this report since only safety research and data related to light trucks and not large trucks was evaluated. Light truck refers to any vehicle definition under Class. ID 2 (Figure 1).

Cumulative raw data tables were created from the National Highway Traffic Safety Administration's (NHTSA) Fatality Analysis Reporting System (FARS). The data was reorganized to only include data relevant to passenger cars and light trucks which were involved in side impact collisions. Side impact collisions are labeled as "angle" collisions in the tables. Only angle collisions which happen at the 3 o'clock and 9 o'clock positions are included in the report. The reasoning for excluding other side impact locations, such as 4 o'clock or 2 o'clock positions, is because the true effectiveness of side impact safety measures is best seen when an impact occurs directly at a 90-degree angle.

Although data will be presented for both single vehicle and multi-vehicle collisions, only data related to single vehicle collisions will be discussed in this report. The reasoning for excluding multi-vehicle collisions is because evaluating only single vehicle crashes is the best way to determine the effectiveness of FMVSS 214. During safety testing, vehicles are only required to pass FMVSS 214 in a single vehicle collision scenario. Since data post 2014 includes

vehicles with standards that were not implemented in the literature reviews from pre 2004, it is to be expected that there will be improved fatality rates. However, the degree of change of these improvements will be a determining factor in deciding what additional improvements can still be made.

1.3 FMVSS 214

The Federal Motor Vehicle Safety Standards are standards which are to be complied with by any vehicle manufacturer in the United States. It is said that FMVSS 214 Side Impact Protection is “one of the most important and promising” FMVSS that was put out by the NHTSA (Kahane, 1999). The original FMVSS 214 Side Impact Protection was a standard effective in 1973 that required passenger cars to pass a static crush resistance test (Walz, 2004). In 1990 this standard was expanded to include light trucks and was implemented beginning with model year (MY) 1994 light trucks and vans (LTV) (Walz, 2004).

The NHTSA did more than just expand the standard to cover LTV, but they also created stricter criteria that manufacturers had to meet. The original FMVSS 214 only required a “static crush requirement” which was a test vehicles had to pass to ensure that they were safe enough for drivers and right front passengers involved in single-vehicle accidents with stationary objects (Walz, 2004). The static test involved driving a steel cylinder into the side doors of vehicles where the door had to have specific levels of resistance at various depths of the crush; this test resulted in the requirement of side door beams in passenger cars (Walz, 2004). The new FMVSS 214 still includes the static crush requirement, but since it was expanded to LTV it became a requirement that LTV had side door beams beginning in MY 1994 (Kahane, 1999). In addendum to the old FMVSS 214 requirements, the NHTSA created a new dynamic test to be included in

the updated FMVSS 214 Side Impact Protection. The dynamic test is meant to simulate a side impact collision between two vehicles at a 90-degree angle (Kahane, 1999).

The dynamic test is carried out using a moving deformable barrier (MDB) which can accurately simulate a 90-degree collision between two vehicles (Kahane, 1999). The test uses side impact dummies (SID) to determine the thoracic trauma index (TTI) that vehicle manufacturers must meet (Kahane, 1999). TTI is the measurement of trauma on a passenger in a collision, during testing TTI(d) is the score measured on the dummy (Kahane, 1999). Through this new dynamic test, the NHTSA determined padding is one additional vehicular modification that should be required in FMVSS 214 to reduce the TTI. Padding can be added to reinforce the side door structures and can absorb large amounts of energy upon impact (Kahane, 1999).

Several years later, another addendum to FMVSS 214 was to include an "oblique 20 mph side impact test with a pole" which was initiated between 2011 and 2015 MY vehicles (Kahane, 2014). Another change the NHTSA began to encourage but never required is installing "torso bags and head air bags" in hopes to lower TTI(d) (Kahane, 2007). Both of these improvements can reduce fatality risk in side impacts by lowering the TTI(d), increase energy absorption and intrusion resistance. Data from 2014 to 2018 will be based on vehicles that follow these two additional improvements and will have an effect on how much fatality risk has changed since the original FMVSS 214.

			Vehicle Type
Class.ID	Classification	Code	Definition
1	Passenger Cars		
		1	Convertible(excludes sun-roof,t-bar)
		2	2-door sedan,hardtop,coupe
		3	3-door/2-door hatchback
		4	4-door sedan, hardtop
		5	5-door/4-door hatchback
		6	Station Wagon (excluding van and truck based)
		7	Hatchback, number of doors unknown
		8	Sedan/Hardtop, number of doors unknown
		9	Other or Unknown automobile type
		10	Auto-based pickup (includes E1 Camino, Caballero, Ranchero, SSR, G8-ST, Subaru Brat, Rabbit Pickup)
		11	Auto-based panel (cargo station wagon, auto-based ambulance or hearse)
		17	3-door coupe
2	Light Trucks		
		79	Unknown truck type (light/medium/heavy)
		79	Unknown truck type (light/medium/heavy)
		34	Light Pickup
		14	Compact Utility (Utility Vehicle Categories "Small" and "Midsize")
		15	Large utility (ANSI D16.1 Utility Vehicle Categories and "Full Size" and "Large")
		16	Utility station wagon (includes suburban limousines, Suburban, Travellall, Grand Wagoneer)
		19	Utility Vehicle, Unknown body type
		20	Minivan (Chrysler Town and Country, Caravan, Grand Caravan, Voyager, Voyager, Honda-Odyssey, ...)
		21	Large Van-Includes van-based buses (B150-B350, Sportsman, Royal Maxiwagon, Ram, Tradesman,...)
		22	Step-van or walk-in van (GVWR less than or equal to 10,000 lbs.)
		28	Other van type (Hi-Cube Van, Kary)
		29	Unknown van type
		33	Convertible pickup
		39	Unknown (pickup style) light conventional truck type
		40	Cab Chassis Based (includes Rescue Vehicle, Light Stake, Dump, and Tow Truck)
		41	Truck based panel
		45	Other light conventional truck type
		48	Unknown light truck type
		49	Unknown light vehicle type (automobile,utility vehicle, van, or light truck)

Figure 1. Vehicle Classifications By Code and Definition

Section 2: FMVSS 214 Effects On Trucks

2.1 Literature Review: 2004 Report by Marie C. Walz

This section will be a review of Walz's report titled "Evaluation of FMVSS 214 Side Impact Protection for Light Trucks: Crush Resistance Requirements for Side Doors" from 2004. The report consists of fatality analysis results of front outboard occupants during a side impact versus a frontal impact, and vehicle exposure crash rates. Both the fatality analysis and the vehicle exposure rates are compared to four years before and after the implementation of side door beams in light trucks. It should be noted that this 2004 report only discusses the data related to the side door beam revision of FMVSS 214 and not the other aspects of the safety standard.

According to Walz, three types of analysis were done to the data before 1994 and after 1994. The first technique was to compare the ratio between frontal impacts and side impacts of trucks with and without the side door beams (Walz, 2004). The second method was creating a ratio between the side impact fatalities and vehicle registration before and after the FMVSS 214 revision (Walz, 2004). Lastly, the most accurate method used was the regression analysis. The regression analysis was able to take other vehicle characteristics into consideration when comparing fatalities before and after the FMVSS 214 revision (Walz, 2004). For example, the regression model could sort and analyze larger amounts of data quickly while also considering if the trucks did or did not have airbags, or whether the vehicle age was a factor of the fatality (Walz, 2004).

In this side door beam study, only 12 o'clock frontal impacts were considered. So, it was most likely guaranteed that the side door beams had no impact on the outcome of this type of crash (Walz, 2004). Frontal impacts were compared with a wider range of side impacts at "the 2,

3, 4, 8, 9 and 10 o'clock positions" (Walz, 2004). A wider range was considered for side impacts since the side door beams would have a significant role in the outcome of these collisions (Walz, 2004). Additionally, the data was separated based on passenger position in relation to the location of the impact. This allowed the results to show whether side door beams had any impact on passengers or drivers when hit on the opposite side of where they were seated; they would be considered a "farside occupant" (Walz, 2004).

2.1.1 Fatality Analysis

Each data point in Table 2, Table 3, and Table 4 represents a fatality for all front occupants, drivers only, and RFP only, respectively. The effectiveness of the use of side door beams is calculated within the tables as well. After comparing the results in all three tables, a conclusive result was determined by Walz. Based on the effectiveness rates it is clear that side door beams are "best at protecting the occupant closest to it." (Walz, 2004). This is especially clear for drivers only due to an adequate amount of data being available. However, the results are inconsistent for RFP due to an insufficient amount of data available (Walz, 2004). Comparing the data from four years before and four years after the implementation of side door beams, there is a clear reduction in fatalities in drivers and all front outboard occupants in side impacted collisions (Walz, 2004).

2.1.2 Vehicle Exposure Crash Rates

The data in Table 5, Table 6, and Table 7 show vehicle exposure crash rates for all front occupants, drivers only, and RFP only, respectively. Each table has fatalities for each respective category for up to four years before and after the implementation of side door beams in light trucks. The fatality rate per 1,000 registered vehicles is included along with the effectiveness rate

and significance test results. A significance test is used to determine if the effectiveness of side door beams was legitimate or possibly just a coincidence. The statistically significant values are marked in the tables with a single asterisk.

Notable improvements were made within the first year of side door beam installation for all occupants, and within all four years for drivers only. Within the first year "fatalities were reduced a statistically significant 16 percent" for all front seat occupants within the FMVSS 214 amendment for light trucks (Walz, 2004). Statistically significant decreases "ranging from 22 to 30 percent" occurred in each of the four years after beam installation for drivers only (Walz, 2004). These significant values were compared to frontal crash fatalities to determine if the changes in fatality coincided or were due to the FMVSS 214 amendment. It was found that "changes in single vehicle frontal fatality rates never exceeded ± 8 percent" (Walz, 2004). Therefore, it can be concluded that the implementation of side door beams in light trucks was a significant factor in reducing the overall fatality rate in side impact collisions.

2.1.3 Regression Analysis

Another factor that has an impact on fatality rate is vehicle age. Vehicle age can be included in a regression analysis to produce more accurate results and expand the number of vehicles used for the analysis. Through the regression analysis, it was confirmed again that drivers only saw the greatest reduction in fatalities in side impact crashes, and all front occupants saw lesser improvements too. For nearside and farside crashes, side door beams directly caused a "fatality reduction…of 19 percent for both drivers alone and for all front outboard occupants," and for only nearside impacts there was a reduction of "26 percent for drivers alone," and "25 percent for all front outboard occupants," (Walz, 2004).

Section 3: FMVSS 214 Effects On Passenger Cars

3.1 Literature Review: 1999 Report by Charles J. Kahane, Ph.D.

This section will be a review of Kahane's report titled "Evaluation of FMVSS 214 – Side Impact Protection: Dynamic Requirement" from 1999. The report consists of an analysis of TTI(d) for front seat occupants compared to real fatalities in passenger cars on highways from before and just after the FMVSS 214 amendment. The FMVSS 214 amendment required that vehicles be tested against a MDB with a passing TTI(d) in order to be acceptable for the public. The test is simulated to imitate a side impact by another passenger car or an object of lesser weight.

Thoracic Trauma Index (TTI) is what is measured in actual crashes whereas TTI(d) is what is measured on dummies during crash testing. A special dummy made for testing only 90-degree side impacts is used for the new FMVSS 214 test. Prior to the FMVSS 214 amendment, structure and padding of were two technologies used to reduce TTI(d) (Kahane, 1999). New technology that has helped to reduce TTI(d) are airbags and side door beams in all vehicles. Kahane concludes that "the lower the TTI(d), the lower the fatality risk" especially for side-impact collisions in 2-door cars (Kahane, 1999). The FMVSS 214 amendment requires that TTI(d) be 90 or less for 2-door sedens and 85 or less in 4-door sedans (Kahane, 1999).

3.1.1 Effect of TTI(d) By Impact Location

There are two components that act when a car is in a side impact collision. These components are "intrusion resistance and energy absorption" (Kahane, 1999). Intrusion resistance is opposition to an object when it hits the side compartment where the car is likely to indent and contact the occupant inside. Energy absorption is used to reduce the risk of harm to

the occupant at any time. During a side impact that is directly centered at the 3 or 9 o'clock positions, both of these components are acting to the fullest extent. However, if the side impact is off-centered, then energy absorption will act more than the intrusion resistance. The TTI(d) during an off-centered collision will be a lot higher since TTI(d) is correlated to intrusion resistance and energy absorption (Kahane, 1999). A 90-degree side impact in a car with good intrusion resistance and energy absorption will have a better TTI(d) (Kahane, 1999).

Table 8 and Table 9 show how the location of an impact affect the TTI(d) rating in 2-door and 4-door cars, respectively. Statistically significant numbers are indicated in each table, meaning a significant number will determine if a good TTI(d) score is related to reduced fatality risk. It can be seen that there are many significant numbers in Table 8 for 2-door cars and there are no significant numbers in Table 9 for 4-door cars. So, it can be concluded that "good TTI(d) score is associated with reduced fatality risk in both nearside and farside impacts of 2-door cars," however, this is not the case for 4-door cars (Kahane, 1999).

3.1.2 Effect of TTI(d) By Type of Vehicle/Object

The TTI(d) can vary based on the object impacting the side of a car. It is important for a vehicle to maintain a good TTI(d) score when coming in contact with a fixed object, or another vehicle such as another car or light truck. Looking at Table 10, it can be seen that for 2-door cars there is a strong correlation of TTI(d) with other passenger cars, and less so with light trucks (Kahane, 1999). Meaning the car performed more closely to the FMVSS-214 dynamic test when colliding with another passenger car rather than a light truck.

The same regression analysis performed for 2-door cars was performed with 4-door cars shown in Table 11. There were not any statistically significant values found when 4-door cars

were side impacted by any type of object. Although there are significant values for 2-doors, it is necessary to create improvements in 4-door passenger cars in order to have a stronger correlation to TTI(d).

Section 4: FMVSS 214 Effectiveness 10 Years Later

4.1 Overview

Using FARS Encyclopedia data tables, Table 1 was created. This table shows data pertaining to fatal crashes in the state of Ohio involving passenger cars and light trucks in side impacted collisions. The rate of side impact collisions for passenger cars only and light trucks only in Ohio was calculated using the total fatal crashes and using the total fatal crashes due to side impacts. The goal of evaluating data 10 years after the FMVSS 214 phase-in, is to see if the rate of fatalities caused by side impacts decreases from the rates found in the older NHTSA reports due to the safety standard.

4.2 Fatality Analysis For Passenger Cars

According to Kahane, approximately 33% of national fatalities were due to side impacted collisions for passenger cars prior to the FMVSS 214 addendums in 1994 (Kahane, 1999). Due to the TTI(d) standards changing, a 23 percent “fatality reduction in side impacts” had occurred for passenger cars. So, post FMVSS 214 changes in 1994, the fatality rate of side impacts in passenger cars was 24.75%. Looking at the fatality rates found in Table 1, it seems that there is an increase in fatality rates in years 2014 through 2016. The fatality rate is the same in 2017 as in post 1994 years and the rate is lower in 2018. Despite at least two additional requirements, a new test and airbags, there is overall no improvement in fatality rates 10 years later.

4.3 Fatality Analysis For Light Trucks

Based on FARS data tables, there was approximately a 17% to 20% fatality rate for light trucks involved in side impacts during the years right after the FMVSS 214 phase-in. Looking at

Table 1, there is an increase in fatality rate between 2014 to 2016. In 2017 and 2018 there is a reduced fatality rate. Similar to the passenger car data, there seems to be no significant improvements in fatality rates despite there being new safety requirements implemented.

Table 1. Fatal Crash Rates, By Vehicle Type, State: Ohio, Years: 2014 to 2018

	Total Fatal Crashes*		Side Impact Fatal Crashes**		Rate of Side Impact Fatalities	
Year	Passenger Cars	Light Trucks	Passenger Cars	Light Trucks	Passenger Cars	Light Trucks
2014	626	494	211	107	34%	22%
2015	684	562	279	188	41%	33%
2016	706	553	316	206	45%	37%
2017	748	567	190	107	25%	19%
2018	650	556	144	79	22%	14%

*Source: (*FARS Encyclopedia: Trends-General*)

**Source: (*FARS Encyclopedia: Vehicles - Light Trucks*) and (*FARS Encyclopedia: Vehicles – Passenger Cars*)

Section 5: Conclusions and Recommendations

5.1 Conclusions

Kahane and Walz both put together comprehensive reports discussing FMVSS 214 standards and their effects on various types of vehicles. Walz's report on "Crush Resistance Requirements" was proof of the improvements that simple safety measures can make. Aside from airbag requirements, adding side door beams to light trucks was one of the single greatest changes to date has saved thousands of lives. Side door beams improved fatality rates in light trucks immediately after implementation occurred in 1994 by upwards of 30 percent in some years.

From Kahane's "Dynamic Performance Requirement" report dated in 1999, it is clear that 2-door cars and 4-door cars act differently when impacted by different objects. There is optimum energy absorption and intrusion resistance when either type of vehicle is impacted from the side. However, improvements to 4-door cars in all scenarios and 2-door cars when impacted by a light truck must be made to reduce fatality risk.

Based on current data pulled from Ohio in 2014 to 2018, it is clear that further analysis needs to be completed. There must be factors other than side door beams, airbags, and crash testing that have contributed to an increased likelihood of dying in a side impact crash. The fact that there was limited data during the time of the NHTSA reports could be causing unrealistic numbers to be used as comparison for this report. For example, the 33% statistic for side impact fatalities, from Kahane, may actually be higher due to underreporting during that time period. In that case, there has still been little to no improvements in the current data. After 1994, the NHTSA started becoming diligent in recording crash stats so the data from their reports prior to

1994 may not be the full picture. Another possibility could be that Ohio naturally has higher fatality rates for side impact collisions than the national average.

In conclusion, the FMVSS 214 had significant impacts on the data at the time of its phase-in for passenger cars and LTV. However, due to possibly incomplete or missing data from the late 1980's and the 1990's, it is hard to tell whether side impact fatality rates have improved since then. More conclusive results could be determined in a future report which compares data from 2000 to 2020 and nationally rather than just the state of Ohio.

5.2 Recommendations

Based on the conclusions in Kahane's report on "Dynamic Performance Requirement," I would recommend improving the dynamic testing to be customized specifically for 2-door cars and 4-door cars. Realistically, 2-door and 4-door vehicles should have to pass different TTI(d) values in different scenarios such as impact by a fixed object, a passenger car, and a light truck. Since each type of vehicle is structurally built different, changing the TTI(d) to be realistic to different types of impacts would be common sense. By having more customized testing based on the type of vehicle and impact objects, I believe that this will allow each type of vehicle to be built to its own optimum potential to reduce fatality risk in various scenarios.

Another report should be completed which compares national data from 2000 to 2020, or only compare data for the state of Ohio from 2000 to 2020. A wider range of data will give more conclusive and accurate results and would allow for more specific recommendations to be made. However, based on the high fatality rates for side impacts in Ohio over the past several years, it is clear that changes need to be made. A determination of the causes of side impacts would be an

ideal study so that safety measures or changes in law could be made to address the causes specifically.

Section 6: References

FARS Encyclopedia: Vehicles - Light Trucks, NHTSA, State: Ohio, Year: 2014 to 2018, www-fars.nhtsa.dot.gov/Vehicles/VehiclesLightTrucks.aspx

FARS Encyclopedia: Vehicles – Passenger Cars, NHTSA, State: Ohio, Year: 2014 to 2018, www-fars.nhtsa.dot.gov/Vehicles/VehiclesPassengerCars.aspx

FARS Encyclopedia: Trends-General, NHTSA, State: Ohio, Year: 1994 to 2018 www-fars.nhtsa.dot.gov/Trends/TrendsGeneral.aspx

Kahane, Charles J. "Evaluation of FMVSS 214 Side Impact Protection Dynamic Performance Requirement." *NHTSA*, USDOT, Oct. 1999, crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/809004.

Kahane, Charles J. "An Evaluation of Side Impact Protection FMVSS 214 TTI(d) Improvements and Side Air Bags." *NHTSA*, USDOT, Jan. 2007, https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/810748.

Kahane, Charles J. "Updated Estimates of Fatality Reduction by Curtain and Side Air Bags in Side Impacts and Preliminary Analyses of Rollover Curtains." *NHTSA*, USDOT, Jan. 2014, https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/811882.

Walz, Marie C. "Evaluation of FMVSS 214 Side Impact Protection for Light Trucks: Crush Resistance Requirements for Side Doors." *NHTSA*, USDOT, Feb. 2004, crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/809719.

Section 7: Appendix

Table 2. Front Outboard Occupant Fatalities, Side vs Frontal Comparisons

Crash Type	One year before and after No Beam	Beam	Two years before and after No Beam	Beam	Three years before and after No Beam	Beam	Four years before and after No Beam	Beam
(1) SV NearSide	123	102	173	142	214	161	232	169
(2) SV FarSide	90	76	118	103	137	114	147	119
(3) SV Pure Frontal	396	380	557	492	665	569	699	587
(4) MV NearSide	212	218	350	300	423	341	442	360
(5) MV FarSide	118	105	179	138	213	161	222	166
(6) MV Pure Frontal	681	588	989	806	1,167	939	1,244	977
Total	1,620	1,469	2,366	1,981	2,819	2,285	2,986	2,378
All Side (1+2+4+5)	543	501	820	683	987	777	1043	814
Frontal (3+6)	1077	968	1546	1298	1832	1508	1943	1564
Effectiveness	**-3%**		**1%**		**4%**		**3%**	
Chi-Square	0.12		0.02		0.57		0.29	
NearSide (1+4)	335	320	523	442	637	502	674	529
Frontal (3+6)	1077	968	1546	1298	1832	1508	1943	1564
Effectiveness	**-6%**		**-1%**		**4%**		**2%**	
Chi-Square	0.46		0.01		0.40		0.14	
Far Side (2+5)	208	181	297	241	350	275	369	285
Frontal (3+6)	1077	968	1546	1298	1832	1508	1943	1564
Effectiveness	**3%**		**3%**		**5%**		**4%**	
Chi-Square	0.09		0.13		0.28		0.23	
SV side (1+2)	213	178	291	245	351	275	379	288
SV Frontal (3)	396	380	557	492	665	569	699	587
Effectiveness	**13%**		**5%**		**8%**		**10%**	
Chi-Square	1.24		0.20		0.80		1.08	

Source: Walz, Marie C. "Evaluation of FMVSS 214 Side Impact Protection for Light Trucks: Crush Resistance Requirements for Side Doors." *NHTSA*, USDOT, Feb. 2004, Exhibit 2a.

Table 2 Continued**.** Front Outboard Occupant Fatalities, Side vs Frontal Comparisons

Crash Type	One year before and after		Two years before and after		Three years before and after		Four years before and after	
	No Beam	Beam	No Beam	Beam	No Beam	Beam	No Beam	Beam
SV NearSide (1)	123	102	173	142	214	161	232	169
SV Frontal (3)	396	380	557	492	665	569	699	587
Effectiveness	**14%**		**7%**		**12%**		**13%**	
Chi-Square	0.92		0.32		1.17		1.51	
SV Far Side (2)	90	76	118	103	137	114	147	119
SV Frontal (3)	396	380	557	492	665	569	699	587
Effectiveness	**12%**		**1%**		**3%**		**4%**	
Chi-Square	0.56		0.01		0.04		0.07	
MV Side (4+5)	330	323	529	438	636	502	664	526
MV Frontal (6)	681	588	989	806	1167	939	1244	977
Effectiveness	**-13%**		**-2%**		**2%**		**-1%**	
Chi-Square	1.69		0.04		0.07		0.01	
MV Nearside (4)	212	218	350	300	423	341	442	360
MV Frontal (6)	681	588	989	806	1167	939	1244	977
Effectiveness	**-19%**		**-5%**		**0%**		**-4%**	
Chi-Square	2.45		0.30		0.00		0.19	
MV Far Side (5)	118	105	179	138	213	161	222	166
MV Frontal (6)	681	588	989	806	1167	939	1244	977
Effectiveness	**-3%**		**5%**		**6%**		**5%**	
Chi-Square	0.04		0.20		0.30		0.20	

Source: Walz, Marie C. "Evaluation of FMVSS 214 Side Impact Protection for Light Trucks: Crush Resistance Requirements for Side Doors." *NHTSA*, USDOT, Feb. 2004, Exhibit 2a Continued.

Table 3. Driver Fatalities Only, Side vs Frontal Comparisons, One to Four Years Before and After Beams Installed

Crash Type	One year before and after		Two years before and after		Three years before and after		Four years before and after	
	No Beam	Beam	No Beam	Beam	No Beam	Beam	No Beam	Beam
(1) SV NearSide	87	65	112	82	124	89	128	90
(2) SV FarSide	76	67	97	82	104	88	110	92
(3) SV Pure Frontal	319	301	418	359	462	414	474	422
(4) MV NearSide	165	161	246	203	265	222	271	228
(5) MV FarSide	84	81	117	102	127	111	128	114
(6) MV Pure Frontal	538	460	722	569	782	640	811	661
Total	1,269	1,135	1,712	1,397	1,864	1,564	1,922	1,607
All Side (1+2+4+5)	412	374	572	469	620	510	637	524
Frontal (3+6)	857	761	1140	928	1244	1054	1285	1083
Effectiveness	**-2%**		**-1%**		**3%**		**2%**	
Chi-Square	0.06		0.01		0.16		0.11	
Nearside (1+4)	252	226	358	285	389	311	399	318
Frontal (3+6)	857	761	1140	928	1244	1054	1285	1083
Effectiveness	**-1%**		**2%**		**6%**		**5%**	
Chi-Square	0.01		0.06		0.45		0.42	
Far Side (2+5)	160	148	214	184	231	199	238	206
Frontal (3+6)	857	761	1140	928	1244	1054	1285	1083
Effectiveness	**-4%**		**-6%**		**-2%**		**-3%**	
Chi-Square	0.11		0.25		0.02		0.07	
SV side (1+2)	163	132	209	164	228	177	238	182
SV Frontal (3)	319	301	418	359	462	414	474	422
Effectiveness	**14%**		**9%**		**13%**		**14%**	
Chi-Square	1.16		0.51		1.41		1.63	

Source: Walz, Marie C. “Evaluation of FMVSS 214 Side Impact Protection for Light Trucks: Crush Resistance Requirements for Side Doors.” *NHTSA*, USDOT, Feb. 2004, Exhibit 2b.

Table 3 Continued. Driver Fatalities Only, Side vs Frontal Comparisons, One to Four Years Before and After Beams Installed

Crash Type	One year before and after		Two years before and after		Three years before and after		Four years before and after	
	No Beam	Beam	No Beam	Beam	No Beam	Beam	No Beam	Beam
SV Nearside (1)	87	65	112	82	124	89	128	90
SV Frontal (3)	319	301	418	359	462	414	474	422
Effectiveness	**21%**		**15%**		**20%**		**21%**	
Chi-Square	1.64		0.97		2.07		2.39	
SV Far Side (2)	76	67	97	82	104	88	110	92
SV Frontal (3)	319	301	418	359	462	414	474	422
Effectiveness	**7%**		**2%**		**6%**		**6%**	
Chi-Square	0.13		0.01		0.13		0.16	
MV Side (4+5)	249	242	363	305	392	333	399	342
MV Frontal (6)	538	460	722	569	782	640	811	661
Effectiveness	**-14%**		**-7%**		**-4%**		**-5%**	
Chi-Square	1.35		0.45		0.17		0.31	
MV Nearside (4)	165	161	246	203	265	222	271	228
MV Frontal (6)	538	460	722	569	782	640	811	661
Effectiveness	**-14%**		**-5%**		**-2%**		**-3%**	
Chi-Square	1.07		0.17		0.05		0.09	
MV Far Side (5)	84	81	117	102	127	111	128	114
MV Frontal (6)	538	460	722	569	782	640	811	661
Effectiveness	**-13%**		**-11%**		**-7%**		**-9%**	
Chi-Square	0.51		0.47		0.22		0.41	

Source: Walz, Marie C. "Evaluation of FMVSS 214 Side Impact Protection for Light Trucks: Crush Resistance Requirements for Side Doors." *NHTSA*, USDOT, Feb. 2004, Exhibit 2b Continued.

Table 4. RF Passenger Fatalities Only, Side vs Frontal Comparisons, One to Four Years Before and After Beams Installed

Crash Type	One year before and after No Beam	One year before and after Beam	Two years before and after No Beam	Two years before and after Beam	Three years before and after No Beam	Three years before and after Beam	Four years before and after No Beam	Four years before and after Beam
(1) SV NearSide	36	37	61	60	90	72	104	79
(2) SV FarSide	14	9	21	21	33	26	37	27
(3) SV Pure Frontal	77	79	139	133	203	155	225	165
(4) MV NearSide	47	57	104	97	158	119	171	132
(5) MV FarSide	34	24	62	36	86	50	94	52
(6) MV Pure Frontal	143	128	267	237	385	299	433	316
Total	351	334	654	584	955	721	1,064	771
All Side (1+2+4+5)	131	127	248	214	367	267	406	290
Frontal (3+6)	220	207	406	370	588	454	658	481
Effectiveness	**-3%**		**5%**		**6%**		**2%**	
Chi-Square	0.04		0.21		0.34		0.06	
Nearside (1+4)	83	94	165	157	248	191	275	211
Frontal (3+6)	220	207	406	370	588	454	658	481
Effectiveness	**-20%**		**-4%**		**0%**		**-5%**	
Chi-Square	1.07		0.11		0.00		0.20	
Far Side (2+5)	48	33	83	57	119	76	131	79
Frontal (3+6)	220	207	406	370	588	454	658	481
Effectiveness	**27%**		**25%**		**17%**		**18%**	
Chi-Square	1.64		2.31		1.42		1.55	
SV side (1+2)	50	46	82	81	123	98	141	106
SV Frontal (3)	77	79	139	133	203	155	225	165
Effectiveness	**10%**		**-3%**		**-4%**		**-3%**	
Chi-Square	0.18		0.03		0.06		0.02	

Source: Walz, Marie C. "Evaluation of FMVSS 214 Side Impact Protection for Light Trucks: Crush Resistance Requirements for Side Doors." *NHTSA*, USDOT, Feb. 2004, Exhibit 2c.

Table 4 Continued**.** RF Passenger Fatalities Only, Side vs Frontal Comparisons, One to Four Years Before and After Beams Installed

	One year before and after		Two years before and after		Three years before and after		Four years before and after	
Crash Type	**No Beam**	**Beam**	**No Beam**	**Beam**	**No Beam**	**Beam**	**No Beam**	**Beam**
SV Nearside (1)	36	37	61	60	90	72	104	79
SV Frontal (3)	77	79	139	133	203	155	225	165
Effectiveness	**0%**		**-3%**		**-5%**		**-4%**	
Chi-Square	0.00		0.02		0.06		0.04	
SV Far Side (2)	14	9	21	21	33	26	37	27
SV Frontal (3)	77	79	139	133	203	155	225	165
Effectiveness	**37%**		**-5%**		**-3%**		**0%**	
Chi-Square	1.06		0.02		0.01		0.00	
MV Side (4+5)	81	81	166	133	244	169	265	184
MV Frontal (6)	143	128	267	237	385	299	433	316
Effectiveness	**-12%**		**10%**		**11%**		**5%**	
Chi-Square	0.31		0.49		0.82		0.17	
MV Nearside (4)	47	57	104	97	158	119	171	132
MV Frontal (6)	143	128	267	237	385	299	433	316
Effectiveness	**-35%**		**-5%**		**3%**		**-6%**	
Chi-Square	1.73		0.09		0.05		0.17	
MV Far Side (5)	34	24	62	36	86	50	94	52
MV Frontal (6)	143	128	267	237	385	299	433	316
Effectiveness	**21%**		**35%**		**25%**		**24%**	
Chi-Square	0.66		3.50		2.24		2.18	

Source: Walz, Marie C. "Evaluation of FMVSS 214 Side Impact Protection for Light Trucks: Crush Resistance Requirements for Side Doors." *NHTSA*, USDOT, Feb. 2004, Exhibit 2c Continued.

Table 5. Front Outboard Occupants, Vehicle Exposure Crash Rates, 1989 through 2000

N of fatalities	One year before and after		Two years before and after		Three years before and after		Four years before and after	
Crash Type	No Beam	Beam	No Beam	Beam	No Beam	Beam	No Beam	Beam
SV Nearside	114	91	153	118	188	131	202	137
SV Farside	78	66	100	87	117	97	125	102
SV Frontal	343	321	477	415	558	484	578	498
MV Nearside	188	196	315	257	378	288	391	299
MV Farside	99	91	155	118	186	132	193	135
MV Frontal	600	505	867	679	1,009	785	1,060	807
Total	1,422	1,270	2,067	1,674	2,436	1,917	2,549	1,978
Vehicle Exposure**	21,863,333	21,356,667	33,756,667	29,370,000	40,413,333	32,940,000	42,916,667	33,896,667
All Frontal&Side Fatalities	1422	1,270	2067	1674	2436	1917	2549	1978
Rate	6.50%	5.95%	6.12%	5.70%	6.03%	5.82%	5.94%	5.84%
Effectiveness	**9%**		**7%**		**3%**		**2%**	
Significance test	***2.32**		***2.19**		**1.15**		**0.59**	
All Side Fatalities	479	444	723	580	869	648	911	673
Rate	2.19%	2.08%	2.14%	1.97%	2.15%	1.97%	2.12%	1.99%
Effectiveness	**5%**		**8%**		**9%**		**6%**	
Significance Test	**0.80**		**1.46**		***1.72**		**1.32**	
Nearside Fatalities	302	287	468	375	566	419	593	436
Rate	1.38%	1.34%	1.39%	1.28%	1.40%	1.27%	1.38%	1.29%
Effectiveness	**3%**		**8%**		**9%**		**7%**	
Significance Test	**0.33**		**1.19**		**1.50**		**1.14**	
Far Side Fatalities	177	157	255	205	303	229	318	237
Rate	0.81%	0.74%	0.76%	0.70%	0.75%	0.70%	0.74%	0.70%
Effectiveness	**9%**		**8%**		**7%**		**6%**	
Significance Test	**0.88**		**0.85**		**0.87**		**0.68**	

* statistically significant at one-tailed 0.05 level

** Vehicle registration years weight by front outboard seat occupancy (1.33)

Source: Walz, Marie C. "Evaluation of FMVSS 214 Side Impact Protection for Light Trucks: Crush Resistance Requirements for Side Doors." *NHTSA*, USDOT, Feb. 2004, Exhibit 3a.

Table 5 Continued. Front Outboard Occupants, Vehicle Exposure Crash Rates, 1989 through 2000

	One year before and after		Two years before and after		Three years before and after		Four years before and after	
SV side Fatalities	192	157	253	205	305	228	327	239
Rate	0.88%	0.74%	0.75%	0.70%	0.75%	0.69%	0.76%	0.71%
Effectiveness	**16%**		**7%**		**8%**		**7%**	
Significance Test	***1.66**		**0.76**		**0.99**		**0.92**	
SV Nearside Fatalities	114	91	153	118	188	131	202	137
Rate	0.52%	0.43%	0.45%	0.40%	0.47%	0.40%	0.47%	0.40%
Effectiveness	**18%**		**11%**		**15%**		**14%**	
Significance Test	**1.44**		**0.99**		**1.39**		**1.39**	
SV Far Side Fatalities	78	66	100	87	117	97	125	102
Rate	0.36%	0.31%	0.30%	0.30%	0.29%	0.29%	0.29%	0.30%
Effectiveness	**13%**		**0%**		**-2%**		**-3%**	
Significance Test	**0.86**		**0.00**		**-0.12**		**-0.24**	
MV Side Fatalities	287	287	470	375	564	420	584	434
Rate	1.31%	1.34%	1.39%	1.28%	1.40%	1.28%	1.36%	1.28%
Effectiveness	**-2%**		**8%**		**9%**		**6%**	
Significance Test	**-0.28**		**1.25**		**1.41**		**0.96**	
MV Nearside Fatalities	188	196	315	257	378	288	391	299
Rate	0.86%	0.92%	0.93%	0.88%	0.94%	0.87%	0.91%	0.88%
Effectiveness	**-7%**		**6%**		**7%**		**3%**	
Significance Test	**-0.64**		**0.77**		**0.87**		**0.42**	
MV Far Side Fatalities	99	91	155	118	186	132	193	135
Rate	0.45%	0.43%	0.46%	0.40%	0.46%	0.40%	0.45%	0.40%
Effectiveness	**6%**		**13%**		**13%**		**11%**	
Significance Test	**0.42**		**1.10**		**1.23**		**1.09**	

* statistically significant at one-tailed 0.05 level

Source: Walz, Marie C. "Evaluation of FMVSS 214 Side Impact Protection for Light Trucks: Crush Resistance Requirements for Side Doors." *NHTSA*, USDOT, Feb. 2004, Exhibit 3a Continued.

Table 5 Continued. Front Outboard Occupants, Vehicle Exposure Crash Rates, 1989 through 2000

	One year before and after		Two years before and after		Three years before and after		Four years before and after	
All Frontal Crash Fatalities	943	826	1,344	1,094	1,567	1,269	1,638	1,305
Rate	4.31%	3.87%	3.98%	3.72%	3.88%	3.85%	3.82%	3.85%
Effectiveness	**10%**		**6%**		**1%**		**-1%**	
Significance Test	***2.29**		**1.64**		**0.17**		**-0.23**	
SV Frontal Fatalities	343	321	477	415	558	484	578	498
Rate	1.57%	1.50%	1.41%	1.41%	1.38%	1.47%	1.35%	1.47%
Effectiveness	**4%**		**0%**		**-6%**		**-9%**	
Significance Test	**0.55**		**0.00**		**-1.00**		**-1.42**	
MV Frontal Fatalities	600	505	867	679	1,009	785	1,060	807
Rate	2.74%	2.36%	2.57%	2.31%	2.50%	2.38%	2.47%	2.38%
Effectiveness	**14%**		**10%**		**5%**		**4%**	
Significance Test	***2.47**		***2.06**		**0.98**		**0.79**	

* statistically significant at one-tailed 0.05 level

Source: Walz, Marie C. "Evaluation of FMVSS 214 Side Impact Protection for Light Trucks: Crush Resistance Requirements for Side Doors." *NHTSA*, USDOT, Feb. 2004, Exhibit 3a Continued.

Table 6. Drivers, Vehicle Exposure Crash Rates, 1989 through 2000

N of fatalities	One year before and after		Two years before and after		Three years before and after		Four years before and after	
Crash Type	No Beam	Beam	No Beam	Beam	No Beam	Beam	No Beam	Beam
SV Nearside	81	56	104	69	116	76	119	76
SV Farside	64	57	80	69	87	75	91	79
SV Frontal	277	253	364	304	404	354	405	359
MV Nearside	149	143	228	172	246	184	247	187
MV Farside	68	69	99	86	108	92	109	93
MV Frontal	469	394	635	488	691	548	698	557
Total	1,108	972	1,510	1,188	1,652	1,329	1,669	1,351
Vehicle Exposure**	15,690,000	15,500,000	23,000,000	19,860,000	25,510,000	21,470,000	26,060,000	21,890,000
All Frontal&Side Fatalities	1108	972	1510	1188	1652	1329	1669	1351
Rate	7.06%	6.27%	6.57%	5.98%	6.48%	6.19%	6.40%	6.17%
Effectiveness	**11%**		**9%**		**4%**		**4%**	
Significance Test	***2.71**		***2.41**		**1.23**		**1.01**	
All Side Fatalities	362	325	511	396	557	427	566	435
Rate	2.31%	2.10%	2.22%	1.99%	2.18%	1.99%	2.17%	1.99%
Effectiveness	**9%**		**10%**		**9%**		**9%**	
Significance Test	**1.25**		**1.62**		**1.46**		**1.40**	
Nearside Fatalities	230	199	332	241	362	260	366	263
Rate	1.47%	1.28%	1.44%	1.21%	1.42%	1.21%	1.40%	1.20%
Effectiveness	**12%**		**16%**		**15%**		**14%**	
Significance Test	**1.37**		***2.07**		***1.97**		***1.95**	
Far Side Fatalities	132	126	179	155	195	167	200	172
Rate	0.84%	0.81%	0.78%	0.78%	0.76%	0.78%	0.77%	0.79%
Effectiveness	**3%**		**0%**		**-2%**		**-2%**	
Significance Test	**0.28**		**-0.03**		**-0.16**		**-0.23**	

* statistically significant at one-tailed 0.05 level
** Vehicle registration years

Source: Walz, Marie C. "Evaluation of FMVSS 214 Side Impact Protection for Light Trucks: Crush Resistance Requirements for Side Doors." *NHTSA*, USDOT, Feb. 2004, Exhibit 3b.

Table 6 Continued. Drivers, Vehicle Exposure Crash Rates, 1989 through 2000

	One year before and after		Two years before and after		Three years before and after		Four years before and after	
SV side Fatalities	145	113	184	138	203	151	210	155
Rate	0.92%	0.73%	0.80%	0.69%	0.80%	0.70%	0.81%	0.71%
Effectiveness	**21%**		**13%**		**12%**		**12%**	
Significance Test	***1.90**		**1.26**		**1.16**		**1.23**	
SV Nearside Fatalities	81	56	104	69	116	76	119	76
Rate	0.52%	0.36%	0.45%	0.35%	0.45%	0.35%	0.46%	0.35%
Effectiveness	**30%**		**23%**		**22%**		**24%**	
Significance Test	***2.07**		***1.72**		***1.72**		***1.89**	
SV Far Side Fatalities	64	57	80	69	87	75	91	79
Rate	0.41%	0.37%	0.35%	0.35%	0.34%	0.35%	0.35%	0.36%
Effectiveness	**10%**		**0%**		**-2%**		**-3%**	
Significance Test	**0.57**		**0.01**		**-0.15**		**-0.21**	
MV Side Fatalities	217	212	327	258	354	276	356	280
Rate	1.38%	1.37%	1.42%	1.30%	1.39%	1.29%	1.37%	1.28%
Effectiveness	**1%**		**9%**		**7%**		**6%**	
Significance Test	**0.12**		**1.09**		**0.96**		**0.83**	
MV Nearside Fatalities	149	143	228	172	246	184	247	187
Rate	0.95%	0.92%	0.99%	0.87%	0.96%	0.86%	0.95%	0.85%
Effectiveness	**3%**		**13%**		**11%**		**10%**	
Significance Test	**0.25**		**1.34**		**1.22**		**1.08**	
MV Far Side Fatalities	68	69	99	86	108	92	109	93
Rate	0.43%	0.45%	0.43%	0.43%	0.42%	0.43%	0.42%	0.42%
Effectiveness	**-3%**		**-1%**		**-1%**		**-2%**	
Significance Test	**-0.16**		**-0.04**		**-0.09**		**-0.11**	

* statistically significant at one-tailed 0.05 level

Source: Walz, Marie C. "Evaluation of FMVSS 214 Side Impact Protection for Light Trucks: Crush Resistance Requirements for Side Doors." *NHTSA*, USDOT, Feb. 2004, Exhibit 3b Continued.

Table 6 Continued. Drivers, Vehicle Exposure Crash Rates, 1989 through 2000

	One year before and after		Two years before and after		Three years before and after		Four years before and after	
All Frontal Crash Fatalities	746	647	999	792	1,095	902	1,103	916
Rate	4.75%	4.17%	4.34%	3.99%	4.29%	4.20%	4.23%	4.18%
Effectiveness	**12%**		**8%**		**2%**		**1%**	
Significance Test	***2.43**		***1.80**		**0.48**		**0.26**	
SV Frontal Fatalities	277	253	364	304	404	354	405	359
Rate	1.77%	1.63%	1.58%	1.53%	1.58%	1.65%	1.55%	1.64%
Effectiveness	**8%**		**3%**		**-4%**		**-6%**	
Significance Test	**0.90**		**0.43**		**-0.55**		**-0.74**	
MV Frontal Fatalities	469	394	635	488	691	548	698	557
Rate	2.99%	2.54%	2.76%	2.46%	2.71%	2.55%	2.68%	2.54%
Effectiveness	**15%**		**11%**		**6%**		**5%**	
Significance Test	***2.38**		***1.94**		**1.04**		**0.90**	

* statistically significant at one-tailed 0.05 level

Source: Walz, Marie C. "Evaluation of FMVSS 214 Side Impact Protection for Light Trucks: Crush Resistance Requirements for Side Doors." *NHTSA*, USDOT, Feb. 2004, Exhibit 3b Continued.

Table 7. RF Passenger Fatalities, Vehicle Exposure Crash Rates, 1989 through 2000

N of fatalities	One year before and after		Two years before and after		Three years before and after		Four years before and after	
Crash Type	No Beam	Beam	No Beam	Beam	No Beam	Beam	No Beam	Beam
SV Nearside	33	35	49	49	72	55	83	61
SV Farside	14	9	20	18	30	22	34	23
SV Frontal	66	68	113	111	154	130	173	139
MV Nearside	39	53	87	85	132	104	144	112
MV Farside	31	22	56	32	78	40	84	42
MV Frontal	131	111	232	191	318	237	362	250
Total	314	298	557	486	784	588	880	627
Vehicle Exposure**	6,173,333	5,856,667	10,756,667	9,510,000	14,903,333	11,470,000	16,856,667	12,006,667
All Frontal&Side Fatalities	314	298	557	486	784	588	880	627
Rate	5.09%	5.09%	5.18%	5.11%	5.26%	5.13%	5.22%	5.22%
Effectiveness	**0%**		**1%**		**3%**		**0%**	
Significance Test	**0.00**		**0.21**		**0.47**		**-0.01**	
All Side Fatalities	117	119	212	184	312	221	345	238
Rate	1.90%	2.03%	1.97%	1.93%	2.09%	1.93%	2.05%	1.98%
Effectiveness	**-7%**		**2%**		**8%**		**3%**	
Significance Test	**-0.53**		**0.18**		**0.95**		**0.38**	
Nearside Fatalities	72	88	136	134	204	159	227	173
Rate	1.17%	1.50%	1.26%	1.41%	1.37%	1.39%	1.35%	1.44%
Effectiveness	**-29%**		**-11%**		**-1%**		**-7%**	
Significance Test	**-1.59**		**-0.89**		**-0.12**		**-0.67**	
Far Side Fatalities	45	31	76	50	108	62	118	65
Rate	0.73%	0.53%	0.71%	0.53%	0.72%	0.54%	0.70%	0.54%
Effectiveness	**27%**		**26%**		**25%**		**23%**	
Significance Test	**1.38**		**1.64**		***1.88**		***1.70**	

* statistically significant at one-tailed 0.05 level

** Vehicle registration years weighted by right-front seat occupancy (0.33)

Source: Walz, Marie C. "Evaluation of FMVSS 214 Side Impact Protection for Light Trucks: Crush Resistance Requirements for Side Doors." *NHTSA*, USDOT, Feb. 2004, Exhibit 3c.

Table 7 Continued. RF Passenger Fatalities, Vehicle Exposure Crash Rates, 1989 through 2000

	One year before and after		Two years before and after		Three years before and after		Four years before and after	
SV side Fatalities	47	44	69	67	102	77	117	84
Rate	0.76%	0.75%	0.64%	0.70%	0.68%	0.67%	0.69%	0.70%
Effectiveness	**1%**		**-10%**		**2%**		**-1%**	
Significance Test	**0.06**		**-0.55**		**0.13**		**-0.06**	
SV Nearside Fatalities	33	35	49	49	72	55	83	61
Rate	0.53%	0.60%	0.46%	0.52%	0.48%	0.48%	0.49%	0.51%
Effectiveness	**-12%**		**-13%**		**1%**		**-3%**	
Significance Test	**-0.46**		**-0.61**		**0.04**		**-0.19**	
SV Far Side Fatalities	14	9	20	18	30	22	34	23
Rate	0.23%	0.15%	0.19%	0.19%	0.20%	0.19%	0.20%	0.19%
Effectiveness	**32%**		**-2%**		**5%**		**5%**	
Significance Test	**0.92**		**-0.05**		**0.17**		**0.19**	
MV Side Fatalities	70	75	143	117	210	144	228	154
Rate	1.13%	1.28%	1.33%	1.23%	1.41%	1.26%	1.35%	1.28%
Effectiveness	**-13%**		**7%**		**11%**		**5%**	
Significance Test	**-0.73**		**0.62**		**1.08**		**0.51**	
MV Nearside Fatalities	39	53	87	85	132	104	144	112
Rate	0.63%	0.90%	0.81%	0.89%	0.89%	0.91%	0.85%	0.93%
Effectiveness	**-43%**		**-11%**		**-2%**		**-9%**	
Significance Test	**-1.70**		**-0.65**		**-0.18**		**-0.69**	
MV Far Side Fatalities	31	22	56	32	78	40	84	42
Rate	0.50%	0.38%	0.52%	0.34%	0.52%	0.35%	0.50%	0.35%
Effectiveness	**25%**		**35%**		**33%**		**30%**	
Significance Test	**1.05**		***2.01**		***2.16**		***1.94**	

* statistically significant at one-tailed 0.05 level

Source: Walz, Marie C. “Evaluation of FMVSS 214 Side Impact Protection for Light Trucks: Crush Resistance Requirements for Side Doors.” *NHTSA*, USDOT, Feb. 2004, Exhibit 3c Continued.

Table 7 Continued. RF Passenger Fatalities, Vehicle Exposure Crash Rates, 1989 through 2000

	One year before and after		Two years before and after		Three years before and after		Four years before and after	
All Frontal Crash Fatalities	197	179	345	302	472	367	535	389
Rate	3.19%	3.06%	3.21%	3.18%	3.17%	3.20%	3.17%	3.24%
Effectiveness	**4%**		**1%**		**-1%**		**-2%**	
Significance Test	**0.42**		**0.13**		**-0.15**		**-0.31**	
SV Frontal Fatalities	66	68	113	111	154	130	173	139
Rate	1.07%	1.16%	1.05%	1.17%	1.03%	1.13%	1.03%	1.16%
Effectiveness	**-9%**		**-11%**		**-10%**		**-13%**	
Significance Test	**-0.48**		**-0.79**		**-0.77**		**-1.05**	
MV Frontal Fatalities	131	111	232	191	318	237	362	250
Rate	2.12%	1.90%	2.16%	2.01%	2.13%	2.07%	2.15%	2.08%
Effectiveness	**11%**		**7%**		**3%**		**3%**	
Significance Test	**0.88**		**0.73**		**0.38**		**0.38**	

* statistically significant at one-tailed 0.05 level

Source: Walz, Marie C. "Evaluation of FMVSS 214 Side Impact Protection for Light Trucks: Crush Resistance Requirements for Side Doors." *NHTSA*, USDOT, Feb. 2004, Exhibit 3c Continued.

Table 8. TTI(d) and Fatality Risk Based on Location of Impact For 2-Door Cars

2-DOOR CARS: INFLUENCE OF THE IMPACT LOCATION ON THE
COEFFICIENT OF TTI(d) IN THE LOGISTIC REGRESSION OF SIDE/PURE-FRONTAL FATALITIES
(front outboard occupants of 2-door cars with no air bags and < 10% ABS)

	IMPACT2	**TTI(d) Regression Coefficient**	**N of Side Impact Fatals**	**Chi-Square**
Baseline (all side impact fatalities)	2,3,4,8,9,10	**.00927**	4,120	13.93**
Occupant compartment impacts	3,9	**.01080**	3,107	16.08**
Off-center impacts	2,4,8,10	**.00510**	1,013	1.57
Nearside impacts	8,9,10 for drivers; 2,3,4 for RF	**.00999**	2,666	12.22**
Farside impacts	2,3,4 for drivers; 8,9,10 for RF	**.00842**	1,454	5.78*
Nearside compartment impacts	9 for drivers; 3 for RF	**.01280**	2,052	16.62**

*TTI(d) coefficient is in the “right” direction and statistically significant at the .05 level.

**TTI(d) coefficient is in the “right” direction and statistically significant at the .01 level.

Source: Kahane, Charles J. “Evaluation of FMVSS 214 Side Impact Protection Dynamic Performance Requirement.” NHTSA, USDOT, Oct. 1999, Table 6-1.

Table 9. TTI(d) and Fatality Risk Based on Location of Impact For 4-Door Cars

4-DOOR CARS: INFLUENCE OF THE IMPACT LOCATION ON THE
COEFFICIENT OF TTI(d) IN THE LOGISTIC REGRESSION OF SIDE/PURE-FRONTAL FATALITIES
(front outboard occupants of 4-door cars weighing 1900-3299 pounds with no air bags and < 10% ABS)

	IMPACT2	**TTI(d) Regression Coefficient**	**N of Side Impact Fatals**	**Chi-Square**
Baseline (all side impact fatalities)	2,3,4,8,9,10	**- .00047**	5,781	.06
Occupant compartment impacts	3,9	**- .00057**	4,409	.08
Off-center impacts	2,4,8,10	**- .00019**	1,372	.004
Nearside impacts	8,9,10 for drivers; 2,3,4 for RF	**- .00113**	3,914	.28
Farside impacts	2,3,4 for drivers; 8,9,10 for RF	**+ .00076**	1,867	.08
Nearside compartment impacts	9 for drivers; 3 for RF	**- .00083**	3,038	.13

No coefficient is statistically significant at the .05 level.

Source: Kahane, Charles J. "Evaluation of FMVSS 214 Side Impact Protection Dynamic Performance Requirement." NHTSA, USDOT, Oct. 1999, Table 6-2.

Table 10. TTI(d) and Fatality Risk Based on Type of Object For 2-Door Cars

2-DOOR CARS:
INFLUENCE OF THE VEHICLE/OBJECT CONTACTED ON THE COEFFICIENT OF TTI(d) IN THE LOGISTIC REGRESSION OF SIDE/PURE-FRONTAL FATALITIES
(front outboard occupants of 2-door cars with no air bags and < 10% ABS)

Side impact with/by	**TTI(d) Regression Coefficient**	**N of Side Impact Fatals**	**Chi-Square**
Baseline (all side impact fatalities)	**.00927**	4,120	13.93**
Fixed object	**.01150**	1,611	8.99**
Any other vehicle	**.00841**	2,509	9.24**
Another passenger car	**.01310**	987	7.51**
Light truck	**.00329**	809	.37
Heavy truck	**.00742**	389	.93
Nearside compartment impact by a passenger car	**.01730**	494	8.26**

**TTI(d) coefficient is in the "right" direction and statistically significant at the .01 level.

Source: Kahane, Charles J. "Evaluation of FMVSS 214 Side Impact Protection Dynamic Performance Requirement." NHTSA, USDOT, Oct. 1999, Table 6-3.

Table 11. TTI(d) and Fatality Risk Based on Type of Object For 4-Door Cars

4-DOOR CARS:
INFLUENCE OF THE VEHICLE/OBJECT CONTACTED ON THE COEFFICIENT OF TTI(d) IN THE LOGISTIC REGRESSION OF SIDE/PURE-FRONTAL FATALITIES
(front outboard occupants of 4-door cars weighing 1900-3299 pounds
with no air bags and < 10% ABS)

Side impact with/by	**TTI(d) Regression Coefficient**	**N of Side Impact Fatals**	**Chi-Square**
Baseline (all side impact fatalities)	**- .00047**	5,781	.06
Fixed object	**+ .00154**	1,088	.21
Any other vehicle	**- .00133**	4,693	.44
Another passenger car	**- .00113**	1,679	.10
Light truck	**+ .00036**	1,653	.01
Heavy truck	**- .00340**	815	.48
Nearside compartment impact by a passenger car	**- .00411**	938	.85

No coefficient is statistically significant at the .05 level.

Source: Kahane, Charles J. "Evaluation of FMVSS 214 Side Impact Protection Dynamic Performance Requirement." NHTSA, USDOT, Oct. 1999, Table 6-4.