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16. Abstract

NHTSA began evaluating the cost of its Federal Motor Vehicle Safety Standards (FMVSS) in 1975. NHTSA's contractors perform detailed engineering teardown analyses for representative samples of vehicles to estimate how much a specific FMVSS added to the weight and the retail price of a vehicle. This process is also known as reverse engineering. This report combines all of these reports and other data sources to estimate the cost and weight added by all the FMVSS, and by each individual FMVSS, to MY 2012 passenger cars and LTVs, and also in all earlier model years, back to 1968. NHTSA estimates that the total cost of safety technologies that are linked to the FMVSS (attributable to a specific standard or voluntarily added in advance of the standard) added an average of $1,929 (in 2012 dollars) and 171 pounds to the average passenger car in MY 2012. An average of $1,808 (in 2012 dollars) and 136 pounds was added to the average LTV in MY 2012. Approximately 7.6 percent of the cost and 5.1 percent of the weight of a model year 2012 passenger car could be linked to the FMVSS, while 5.3 percent of the cost and 2.9 percent of the weight of a model year 2012 LTV could be linked to the FMVSS.

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TABLE OF CONTENTS

LIST OF ABBREVIATIONS

ABS	antilock brake system
AMC	American Motors Corporation
ANPRM	Advance Notice of Proposed Rulemaking
ANSI	American National Standard Institute
BMW	Bayerische Motoren Werke
CFR	Code of Federal Regulations; up-to-date text of NHTSA regulations may be downloaded from the electronic CFR, Title 49, www.ecfr.gov/cgi-bin/text-idx?c=ecfr&tpl=/ecfrbrowse/Title49/49tab_02.tpl. Regulations other than FMVSS are referenced as Part numbers (e.g., Part 563, Event data recorders).. FMVSS are referenced as Part 571 followed by the FMVSS number (e.g., Part 571.103 = FMVSS No. 103, Windshield defrosting and defogging systems)
CHMSL	center high-mounted stop lamp
CNG	compressed natural gas
CUV	crossover utility vehicle
CY	calendar year
DRL	daytime running lights
EAD	energy-absorbing device on a steering column
ESC	electronic stability control
FARS	Fatality Analysis Reporting System (a census of fatal crashes in the United States since 1975)
FMVSS	Federal Motor Vehicle Safety Standard
GAAP	generally accepted accounting principles
GDP	gross domestic product - The GDP deflator (implicit price deflator for GDP) is a measure of the level of prices of all new, domestically produced, final goods and services in the United States in a specified year.
GM	General Motors
GVWR	gross vehicle weight rating (specified by the manufacturer, equals the vehicle's curb weight plus maximum recommended loading)

HIC	head injury criterion
HPR	high penetration resistant windshield
LATCH	lower anchors and tethers for children
LED	light-emitting diode
LTVs	light trucks and vans (includes pickup trucks, SUVs, CUVs, minivans and full-sized vans with GVWR of 10,000 pounds or less)
MPV	multipurpose passenger vehicle (includes SUVs, CUVs, minivans and full sized vans designed to carry people, with rear windows - not a cargo van, with GVWR or 10,000 pounds or less)
MY	model year
NASS	National Automotive Sampling System (a probability sample of police-reported crashes in the United States since 1979, investigated in detail)
NCAP	New Car Assessment Program (consumer information supplied by NHTSA on the safety of new cars and LTVs, based on test results, since 1979)
NCSA	NHTSA's National Center for Statistics and Analysis
NCSS	National Crash Severity Study (a probability sample of police-reported towaway crashes in seven multicounty areas, 1977-79, investigated in detail)
NPRM	Notice of Proposed Rulemaking
RF	right front
RPE	retail price equivalent
SNPRM	Supplemental Notice of Proposed Rulemaking
SUV	sport utility vehicle
TPMS	tire pressure monitoring system
TREAD Act	Transportation Recall Enhancement, Accountability, and Documentation Act
TTI	thoracic trauma index
TTI(d)	thoracic trauma index for the dummy in a side-impact test
UMTRI	University of Michigan Transportation Research Institute
VW	Volkswagen

ACKNOWLEDGMENTS

In 1975 NHTSA proposed to evaluate the costs as well as the benefits of existing Federal Motor Vehicle Safety Standards. Warren LaHeist, under the general direction of Frank Ephraim, planned to estimate costs based on teardown or reverse engineering. The first contract to evaluate costs of specific FMVSS was awarded in 1977 and completed in 1978. From 1978 to 2001 Robert Lemmer, Bruce Spinney, Gregory Rymarz, or LaHeist managed the cost-analysis program. Spinney also developed NHTSA's macro-analysis for computing mark-ups from direct variable costs to final consumer costs.

A report summarizing the cost analyses and estimating the overall consumer cost of the FMVSS was proposed first in NHTSA's 1998-to-2002 Evaluation Plan and again in the 2004-to-2007 plan. LaHeist outlined the report in 1998 to 1999 and drafted text for some of the FMVSS. After LaHeist retired, Rymarz worked up initial spreadsheets and/or text for many of the remaining FMVSS in 1999 to 2001. Marcia Tarbet was assigned to the cost-analysis program, when she joined NHTSA in 2002, and completed the report in 2004. NHTSA proposed to update the 2004 report in its 2008 to 2012 Evaluation Plan. Jennifer Dang headed the cost-analysis program after Tarbet retired in 2007. Shirley Florus was assigned to head the cost-analysis program when she joined NHTSA in 2008 and coordinated all of the cost teardown contracts and contractors since that time. Dr. Charles Kahane was the Evaluation Division chief from 1995 to 2014 and James Simons was the director of the Office of Regulatory Analysis and Evaluation from 1998 to 2014. Both supervised the development of the 2004 Cost Report completed by Tarbet. With the help of Dr. Kahane, Simons updated this report under the guidance of Lawrence Blincoe of NHTSA.

EXECUTIVE SUMMARY

The National Highway Traffic Safety Administration issues Federal Motor Vehicle Safety Standards for new motor vehicles and equipment to reduce the number of crashes and the risk of deaths and injuries. The 100-series FMVSS are crash avoidance standards, the 200-series regulates crashworthiness, while the 300-, 400- and 500-series address the risk of fires, hazards during normal operation, and certain special vehicles. Manufacturers of new vehicles and equipment must conform and certify compliance to the FMVSS. The initial FMVSS went into effect on January 1, 1968.

NHTSA began to evaluate the cost of the FMVSS in 1975. NHTSA's contractors perform detailed engineering "teardown" analyses, for representative samples of vehicles, to estimate how much specific FMVSS add to the weight and the retail price of a vehicle. These analyses employ a process known as reverse engineering. Whereas conventional engineering proceeds from design and raw materials to mass-produced product, reverse engineering includes a step-by-step teardown or disassembly of each finished item into sub-assemblies and finally into individual component parts. The contractor weighs the components, identifies the type, unit cost and amount of raw material needed, identifies the processes to make the parts, and estimates the labor, variable burden, and tooling required to produce individual components and assemble them. These direct variable costs determined by the contractor are then marked up by a 1.51 factor determined by NHTSA to account for manufacturer's fixed costs and dealer markups to derive a retail price equivalent consumer cost.

NHTSA and its contractors have evaluated virtually all the cost- and weight-adding technologies introduced in passenger cars and LTVs (light trucks and vans including pickup trucks, SUVs, crossover utility vehicles, minivans and full-sized vans with GVWR of 10,000 pounds or less) in response to the FMVSS. NHTSA has estimated the cost and weight added by all the FMVSS, and by each individual FMVSS, to MY 2012 passenger cars and LTVs, and also in all earlier MYs, back to 1968. All costs are estimated in 2012 dollars. All of the contractor studies completed to date are available in one NHTSA docket at www.regulations.gov. Search under docket number NHTSA-2011-0066. For some of the more recent FMVSS or recent amendments to FMVSS (like FMVSS No. 139 – new pneumatic radial tires for light vehicles, FMVSS No. 202 – head restraints upgrade, FMVSS No. 216 – roof crush resistance upgrade, FMVSS No. 226 - ejection mitigation), where a cost teardown analysis has not been completed, this analysis uses estimates from NHTSA's regulatory analyses. This report updates Marcia Tarbet's December 2004 report, *Cost and Weight Added by the Federal Motor Vehicle Safety Standards for Model Years 1968-2001 in Passenger Cars and Light Trucks* (Report No. DOT HS 809 834).

The "attributable" cost of an FMVSS, in this report, includes the cost of all equipment or specific safety technologies added or modified primarily for the purpose of meeting (or even exceeding) the requirements of the standard, provided these modifications took place after the baseline model year. The baseline model year is defined as the last model year in production as of September 1 before a Notice of Proposed Rulemaking was published in the Federal Register. The baseline installation rate of safety technologies, and installations before the baseline year, are considered "voluntary" installation by the manufacturers. Attributable costs will be the difference between the installation rates for model years after the baseline year through MY 2012 minus the voluntary baseline level. If safety equipment was already in place in 100 percent of the fleet before an NPRM (in the baseline year), and was not modified in response to any FMVSS, its cost will not be attributed to the FMVSS and will not be considered voluntarily supplied by the manufacturers. The only exceptions to these rules are lap belts, which were required by several States before NHTSA was established. Lap belts are considered attributable to safety standards, even though those standards weren't strictly FMVSS (but State standards), and even though we can't define a baseline year using a NHTSA published NPRM.

The cost of an FMVSS is the incremental cost over the equipment that was there before the standard and likely would have remained there without the standard. The cost of these technologies will tend to decline over time as companies learn how to make the products more efficiently, and as their production volumes increase. As manufacturers gain production experience, they refine component designs, manufacturing techniques and assembly methods, and optimize raw material and component sources. This learning process enables them to maximize efficiency and reduce production costs. In this report, unlike the 2004 report, we estimate the effect of this learning curve on costs that are derived from teardown studies conducted on older model year's vehicles.

The "voluntary" cost of safety technologies installed by manufacturers includes safety modifications that took place in model years before an NPRM. In addition, voluntary compliance after the NPRM is assumed to be the same as the last model year before the NPRM. Thus, if the NPRM were published in June 2001, the previous September 1, or September 1, 2000 (or MY 2001) is considered the baseline year in this analysis. Voluntary compliance for MYs 2002 to MY 2012 is assumed to be at the same level as compliance in the baseline year of MY 2001. In other words, we assume that without the rulemaking voluntary compliance would have stayed at the same level as it was in the baseline year for all years through MY 2012 (see Appropriate Baseline Year section of Chapter 1 for a numerical example).

The report does not include technologies so recent that NHTSA has not proposed them as of June 1, 2014, (roughly the start of writing this report). There are many other potential safety technologies that are installed in some vehicles today for which NHTSA has not started a rulemaking. These are not captured in this analysis. Not included in our analysis, because they have not been proposed as part of an FMVSS, are safety features such as forward collision warning and/or automatic braking, adaptive automatic cruise control, lane departure warning, lane keeping systems, blind spot warning, etc.

Furthermore, the report is limited to passenger cars and LTVs; the cost of FMVSS in heavy trucks, buses, or motorcycles has not been estimated, nor has the cost of motor vehicle equipment, such as child restraints, been included.

The Cost and Weight Added by the FMVSS in MY 2012. NHTSA estimates that the total cost of safety technologies (attributable and voluntarily added) that are linked to the FMVSS added an average of $1,929 (in 2012 dollars) and 171 pounds to the average passenger car in MY 2012 (see Table 1a). Since passenger cars cost an average of $25,553 (in 2012 dollars)[1] and weighed

[1] National Highway Traffic Safety Administration. (2009, August). Preliminary regulatory impact analysis,

3,380 pounds in MY 2012, 7.6 percent of the cost and 5.1 percent of the weight of a new MY 2012 passenger car could be linked to the FMVSS. Of the total of 171 pounds added, 132 pounds (77%) are attributable and 39 pounds (23%) are voluntary. Of the total $1,929 cost added, $1,346 (70%) is attributable and $583 (30%) is voluntary.

An average of $1,808 (in 2012 dollars) and 136 pounds was added to the average LTV in model year 2012 and was linked to the FMVSS (see Table 1b). With LTVs costing an average of $34,078 (in 2012 dollars) and weighing 4,687 pounds in MY 2012, 5.3 percent of the cost and 2.9 percent of the weight of a new LTV could be linked to the FMVSS. For MY 2012, of the total of 136 pounds added, 92 pounds (68%) are attributable and 44 pounds (32%) are voluntary. Of the total $1,808 cost added, $1,074 (59%) is attributable and $735 (41%) is voluntary.

We use the term "average" cost to designate that the cost of the technology has been multiplied by the percentage of the fleet equipped with the safety technology. There could be several reasons affecting the percentage of vehicles equipped. First, before a requirement, manufacturers may have supplied the safety countermeasure in only a few make/models or to their higher priced models. Second, the effective dates of a requirement may be phased-in over time (for example, 35 percent of the vehicles must meet the standard in the first year, 70 percent of the vehicles in the second year, and 100 percent of the vehicles in year three and thereafter). Third, the standard might not affect all passenger cars, for example, not all passenger cars have seat back locks, because seat back locks were only used on 2-door cars. Thus, if the safety technology costs $100 and 50 percent of passenger cars in MY 2012 are equipped with that safety technology, the increased cost of the average passenger car is $50.

There are a total of 38 safety technologies for which weights and costs are included in Table 1a for passenger cars and 32 safety technologies for which weights and costs are included in Table 1b for LTVs. We counted lap belts, lap/shoulder belts, air bags, and head restraints each as 1 safety technology. We did not count each of the different seat positions for those 4 technologies as a different safety technology. The 6 technologies with costs for MY 2008 to MY 2012 for passenger cars that did not have costs for LTVs included: FMVSS No. 207 seat back locks, FMVSS No. 208 automatic belts, FMVSS No. 214 side impact dynamic test, FMVSS No. 216 roof crush initial standard, FMVSS No. 216 roof crush upgraded standard, and FMVSS No. 401 interior trunk release. There are 3 safety technologies included for LTVs that were not included for passenger cars (FMVSS No. 105 warning brake light switch, FMVSS No. 206 for sliding doors, and FMVSS No. 226 a voluntary ejection mitigation window curtain), making a total of 41 different safety technologies for which weights and costs were estimated and included in the summary tables of this report. Not all of these safety technologies occur in each year, for example lap belts may occur in the early years and lap/shoulder belts in the following years through MY 2012. There are a few other safety technologies for which we have discussed weights and costs but those safety technologies have not been included in the summary Tables 1a and 1b, because they were installed in 100 percent of the fleet before the baseline year.

Corporate Average Fuel Economy for MY 2012-2016 passenger cars and LTVs. In Docket No. 2009-0059-0016. Retail prices based on average consumer expenditures by the Bureau of Economic Analysis for 2012 for passenger cars and LTVs. Source is Table 7.2.5S, Auto and Truck Unit Sales, Production, Inventories, Expenditures, and Price. www.bea.gov/itable/. The average weights are based on MY 2011 manufacturers' confidential plans sent to NHTSA and assumed to remain the same for MY 2012.

Table 1a						
Weight (lb) and Cost (2012$) Per Average Vehicle of All Safety Technology Voluntarily Supplied or Attributable to the FMVSS by Model Year						
Passenger Cars						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	6.52	13.96	20.48	$60.70	$163.11	$223.81
1969	13.64	17.97	31.60	$76.69	$206.67	$283.35
1970	14.04	25.37	39.41	$77.36	$229.95	$307.30
1971	14.47	28.22	42.69	$78.49	$233.58	$312.07
1972	17.40	33.90	51.30	$101.68	$254.80	$356.48
1973	17.93	47.16	65.10	$104.88	$281.77	$386.64
1974	17.87	53.68	71.55	$112.29	$291.41	$403.70
1975	17.73	53.56	71.29	$112.04	$291.74	$403.78
1976	17.54	55.80	73.34	$112.16	$315.16	$427.32
1977	15.31	53.64	68.95	$102.60	$305.31	$407.90
1978	14.96	52.69	67.65	$101.84	$304.12	$405.96
1979	14.67	50.93	65.60	$99.61	$295.46	$395.06
1980	14.91	51.03	65.94	$99.02	$294.43	$393.45
1981	14.74	50.48	65.23	$99.60	$293.24	$392.85
1982	14.56	49.80	64.36	$98.32	$290.33	$388.64
1983	14.44	49.28	63.72	$98.23	$288.32	$386.55
1984	14.38	49.04	63.42	$96.63	$286.16	$382.79
1985	14.21	48.57	62.79	$94.61	$285.11	$379.72
1986	14.77	49.10	63.88	$122.00	$296.37	$418.37
1987	15.54	50.38	65.93	$142.75	$319.71	$462.46
1988	15.26	51.95	67.21	$138.05	$338.88	$476.94
1989	15.62	53.26	68.87	$141.02	$361.44	$502.47
1990	17.51	62.37	79.88	$161.19	$542.09	$703.28
1991	18.54	61.97	80.51	$195.31	$553.51	$748.83
1992	21.89	60.56	82.45	$291.79	$560.31	$852.11
1993	24.57	63.38	87.95	$336.71	$613.24	$949.95
1994	28.62	76.21	104.83	$408.66	$746.11	$1,154.77
1995	28.74	88.59	117.33	$403.03	$842.91	$1,245.94
1996	28.93	96.88	125.81	$406.52	$867.41	$1,273.92
1997	28.79	108.72	137.51	$401.76	$894.91	$1,296.67
1998	29.78	107.80	137.59	$427.58	$874.25	$1,301.83

1999	30.99	106.44	137.43	$459.40	$853.25	$1,312.65
2000	31.57	105.75	137.31	$470.38	$835.27	$1,305.65
2001	32.63	104.68	137.31	$494.66	$816.97	$1,311.63
2002	33.19	103.59	136.78	$503.31	$798.79	$1,302.10
2003	33.36	103.02	136.38	$494.81	$782.56	$1,277.36
2004	34.68	103.89	138.57	$522.83	$833.07	$1,355.89
2005	35.72	103.77	139.49	$529.69	$818.96	$1,348.65
2006	37.08	105.79	142.87	$576.11	$860.44	$1,436.55
2007	37.70	114.22	151.92	$591.03	$945.07	$1,536.10
2008	37.98	122.84	160.82	$590.78	$1,121.83	$1,712.62
2009	38.05	129.19	167.24	$587.53	$1,193.62	$1,781.15
2010	38.05	131.44	169.48	$586.45	$1,291.74	$1,878.19
2011	38.98	130.45	169.43	$596.70	$1,309.75	$1,906.45
2012	38.70	132.73	171.43	$582.78	$1,346.66	$1,929.43

Table 1b

Weight (lb) and Cost (2012$) Per Average Vehicle of All Safety Technology Voluntarily Supplied or Attributable to the FMVSS by Model Year

LTVs

Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	3.23	7.27	10.50	$25.31	$96.34	$121.64
1969	3.34	7.27	10.60	$23.82	$96.16	$119.97
1970	3.49	7.76	11.25	$24.86	$106.47	$131.33
1971	3.59	7.76	11.35	$25.17	$106.35	$131.52
1972	3.65	14.28	17.93	$26.52	$148.24	$174.76
1973	4.87	16.04	20.91	$42.82	$158.51	$201.33
1974	7.31	14.24	21.54	$72.20	$137.61	$209.81
1975	7.56	15.77	23.33	$74.27	$145.38	$219.65
1976	8.08	16.65	24.73	$77.54	$149.80	$227.35
1977	9.31	17.12	26.43	$98.99	$151.36	$250.35
1978	9.63	17.23	26.86	$99.76	$150.29	$250.05
1979	10.08	16.62	26.70	$102.22	$151.88	$254.11
1980	10.60	16.92	27.52	$107.94	$152.50	$260.44
1981	10.89	16.69	27.58	$110.89	$148.60	$259.49
1982	10.89	19.50	30.38	$110.35	$166.12	$276.47
1983	11.58	19.81	31.40	$116.61	$166.93	$283.54
1984	11.85	19.91	31.76	$118.51	$166.36	$284.87
1985	12.15	20.15	32.30	$120.50	$166.57	$287.07

1986	12.24	20.31	32.55	$120.49	$166.36	$286.85
1987	18.09	21.84	39.93	$283.00	$179.31	$462.31
1988	22.33	21.91	44.24	$364.01	$178.66	$542.67
1989	30.93	21.88	52.81	$520.51	$177.87	$698.38
1990	37.74	22.33	60.08	$614.08	$181.26	$795.34
1991	35.34	24.13	59.48	$620.10	$184.04	$804.14
1992	32.02	27.00	59.02	$606.54	$238.32	$844.86
1993	33.20	28.91	62.10	$603.07	$261.27	$864.34
1994	33.84	44.39	78.22	$583.98	$337.02	$921.00
1995	35.70	54.85	90.56	$606.42	$543.62	$1,150.04
1996	35.28	60.17	95.44	$595.93	$630.12	$1,226.05
1997	35.09	62.54	97.64	$595.99	$656.47	$1,252.45
1998	34.54	64.67	99.20	$593.58	$688.03	$1,281.61
1999	34.31	62.99	97.30	$589.79	$671.21	$1,261.01
2000	34.63	61.26	95.89	$590.92	$653.33	$1,244.25
2001	35.28	60.11	95.39	$606.47	$637.70	$1,244.17
2002	36.28	59.18	95.46	$622.12	$626.92	$1,249.04
2003	38.52	58.55	97.07	$640.21	$610.26	$1,250.47
2004	39.39	59.39	98.78	$643.25	$699.72	$1,342.97
2005	41.00	60.20	101.20	$653.82	$703.08	$1,356.90
2006	41.68	61.20	102.88	$676.26	$696.45	$1,372.71
2007	42.49	71.74	114.24	$707.15	$780.04	$1,487.19
2008	43.63	78.71	122.33	$741.95	$897.56	$1,639.51
2009	43.49	88.22	131.71	$742.37	$995.63	$1,738.00
2010	43.00	92.44	135.45	$749.51	$1,063.00	$1,812.51
2011	44.03	92.11	136.15	$743.38	$1,076.48	$1,819.85
2012	43.73	92.51	136.25	$733.48	$1,074.46	$1,807.94

Table 2 presents the average weight and cost for passenger cars and LTVs that are voluntarily supplied or attributable for MY 2012 that are linked to the FMVSS by their standard number with a description of the safety countermeasure.

Table 2					
Weight (lb) and Cost (2012$) Per Average Vehicle of All Safety Technology Voluntarily Supplied or Attributable to the FMVSS in MY 2012					
FMVSS	**Description**	**Passenger Cars**		**LTVs**	
		Weight	**Cost**	**Weight**	**Cost**
105	Antilock Braking System	10.7	$387.05	10.7	$387.05
105	Power Booster	7.9	$41.03	7.9	$41.03
105	Brake Warning Light	0.0	$0.00	0.0	$0.44
108	Side Marker Lamps	1.3	$33.36	1.3	$33.36
108	Center High Mounted Stop Lamps	0.9	$8.38	0.9	$8.38
111	Rear Visibility Cameras	0.8	$27.19	0.8	$38.53
118	Power Windows	0.0	$0.86	0.0	$0.81
124	Accelerator Controls	0.0	$0.48	0.0	$0.48
126	Electronic Stability Control	1.8	$102.54	1.8	$102.54
138	Tire Pressure Monitoring System	1.7	$165.62	1.7	$165.62
139	Tire Upgrade	0.0	$0.23	0.0	$0.23
201	Seat Back, Instrument Panel Padding, Glove Box	0.7	$4.10	4.1	$18.86
201	Upper Interior Protection	1.9	$11.66	1.9	$11.66
202	Head Restraints Front Outboard	2.8	$36.47	5.5	$40.88
202	Head Restraints Rear	9.6	$52.82	14.2	$55.91
203/204	Steering Assembly	1.9	$24.32	1.9	$24.32
206	Door Locks, Sliding Doors on LTVs	0.0	$0.00	0.2	$1.19
207	Seat Back Locks	0.5	$2.35	0.0	$0.00
208	Seat Belts	18.2	$180.47	21.0	$198.52
208	Frontal Air Bags	12.8	$336.98	12.8	$336.98
214	Side Door Beams	24.5	$53.03	15.0	$16.73
214	Dynamic Test	38.4	$124.80	0.0	$0.00
214	Side Air Bags/Window Curtains	14.6	$270.36	19.0	$248.90
216	Roof Crush Initial Standard	2.9	$2.93	0.0	$0.00
216	Roof Crush Upgrade	1.4	$3.89	0.0	$0.00
225	LATCH - Lower Anchors and Tethers for Children	1.7	$5.59	1.5	$5.11
226	Ejection Mitigation - Rollover Sensor	0.0	$3.92	0.3	$25.33
301	Fuel System Integrity 1976-78	2.5	$13.46	2.5	$13.46
301	Fuel System Integrity - 2007-2009	12.0	$33.72	11.2	$31.62
401	Interior Trunk Release	0.1	$1.82	0.0	$0.00
	Total	171.4	$1,929.43	136.2	$1,807.94

Those technologies that contributed most significantly to the cost and weight of a passenger car and LTV (ranked by total cost) as of MY 2012 are:

- **Antilock Braking Systems (ABS) and Electronic Stability Control).** ABS became attributable when electronic stability control in FMVSS No. 126 was proposed because ABS provides the basic elements necessary for ESC to function properly. ABS was voluntarily supplied in some vehicles starting in 1986 and became attributable starting in MY 2008 for that percentage of the passenger car and LTV fleet that was not already voluntarily supplied with ABS in MY 2007 (the baseline year). ABS is the single most costly countermeasure ($387.05) and is much more costly than ESC ($102.54), but ESC needs the ABS components to function properly. Together these technologies add $489.60 and 12.5 pounds to both passenger cars and LTVs in MY 2012. For MY 2012, the portion of these costs that are attributable to the FMVSS for passenger cars are $89.41 for ABS and $81.86 for ESC, totaling $171.27 or about 35 percent of the total $489.60 cost. The portion of these costs that are attributable to the FMVSS for LTVs are $20.90 for ABS and $51.84 for ESC, totaling $72.75 or about 15 percent of the total $489.60 cost.

- **Frontal Air Bags.** By the late 1990s, passenger cars and LTVs were equipped with a frontal air bag at both the driver's and right front passenger's seating position. Air bag designs have changed several times over the years with depowering, occupant sensing, and multi-stage inflators. Dual frontal air bags add $336.98 and 12.8 pounds to passenger cars and LTVs as of MY 2012. For MY 2012, all of these costs are attributable to the FMVSS because, except for small test fleets, all air bags were introduced subsequent to the October 14, 1983, NPRM.

- **Side Air Bags and Window Curtains**. Torso air bags were voluntarily introduced in some vehicles in 1996 and window curtains to protect the head were voluntarily introduced in some vehicles in 1998. Window curtains have become wider over time as NHTSA required a pole test at an oblique angle with both a mid-seating position for a 50th percentile male dummy and a forward seating position for a 5th percentile female dummy. In MY 2012, torso bags for the front outboard seats were installed in almost 100 percent of passenger cars and 77 percent of LTVs while window curtains, which covered up to three rows of seats (could be 1 row in a regular cab pickup, two rows in a passenger car, three rows in minivans and some SUVs, and four rows of seats in a 15-passenger full sized vans), were installed in almost 100 percent of passenger cars and 90 percent of LTVs. The combined cost and weight of these two types of air bags for passenger cars as of MY 2012 was $270.36 and 14.6 pounds, while for the average LTV at the equipment installation rates, it was $248.90 and 19.0 pounds. For MY 2012, the portion of these costs that are attributable to the FMVSS are $215.73 for passenger cars or about 80 percent of the total $270.36 cost. For MY 2012, the portion of these costs that are attributable to the FMVSS are $211.62 for LTVs or about 85 percent of the total $248.90 cost.

- **Seat Belts**. The primary component of the occupant protection system is the seat belt. They are highly effective in saving lives and preventing serious injuries in rollovers, frontal crashes, and many types of side impacts. Seat belts evolved from lap belts with manual adjustments to manual 3-point belts that combine the lap belt and shoulder harness into a single device with locking retractors. All front and rear outboard seats, and rear center seats are now equipped with manual 3-point belts. The front center seat, for example in pickup trucks, can still be equipped with a manual lap belt. Pretensioners, load limiters, and adaptable anchorages are included with these seat belt estimates. Together these seat belt technologies add $180.47 and 18.2 pounds to passenger cars and $198.52 and 21.0 pounds to the average LTV as of MY 2012. For MY 2012, the portion of these costs that are attributable to the FMVSS are $98.11 for passenger cars or about 54 percent of the total $180.47 cost. For MY 2012, the portion of these costs that are attributable to the FMVSS are $85.58 for LTVs or about 47 percent of the total $198.52 cost.

- **Tire Pressure Monitoring Systems**. Direct TPMS systems were voluntarily introduced in some vehicles in 2001and were required in all passenger cars and LTVs in MY 2008. The cost and weight for direct TPMS in both passenger cars and LTVs for MY 2012 is $165.62 and 1.7 pounds. For MY 2012, the portion of these costs that are attributable to the FMVSS are $162.13 for passenger cars or about 98 percent of the total $165.62 cost. For MY 2012, the portion of these costs that are attributable to the FMVSS are $164.93 for LTVs or 99.6 percent of the total $165.62 cost.

- **Side Impact Protection – Dynamic Crash Test as it Affected Passenger Cars**. For passenger cars, vehicle side structures were substantially reinforced and padded to meet NHTSA’s dynamic crash tests effective for all passenger cars in MY 1997. LTVs already passed the dynamic test without additional countermeasures. These changes add $124.80 and 38.4 pounds to MY 2012 passenger cars. All of these costs are attributable to the FMVSS.

Three of the top four increases in weight as of MY 2012 are from side impact standards. The dynamic crash test requirement of FMVSS No. 214 added 38.4 pounds to passenger cars, side door beams added 24.5 pounds to passenger cars and 15.0 pounds to LTVs, and side air bags added 14.6 pounds to passenger cars and 19.0 pounds to LTVs. Together these three side impact improvements added 45.2 percent (77.5 out of 171.4 pounds) of the total weight increase for passenger cars and 25.0 percent (34.0 out of 136.2 pounds) of the total weight increase for LTVs of all weight added by the FMVSS for MY 2012. Of the 77.5 pounds added by FMVSS No. 214 for passenger cars, 70.2 pounds (about 91%) are attributable to the FMVSS. Of the 34.0 pounds added by FMVSS No. 214 for LTVs, 32.0 pounds (about 94%) are attributable to the FMVSS.

Seat belts added 18.2 pounds for passenger cars (of which 11.3 pounds or 62% are attributable to the FMVSS) and 21.0 pounds for LTVs (of which 13.0 pounds or 62% are attributable to the FMVSS) for MY 2012.

Historical trend of the cost and weight added by the FMVSS for MY 1968-2012.
Table 1a and Table 1b show the weight and cost voluntarily supplied and attributable by the FMVSS in vehicles of each model year from 1968 to 2012. There is not a steady progression in the weight and cost of the FMVSS over time because of three factors. The first is the downsizing

of the fleet. You'll notice the weight of passenger cars decreases starting in 1976 to 1985. Downsizing can only be discerned in our analysis when we have cost teardown studies of the same FMVSS in two or more time periods. There are only six safety technologies for which we have two or more cost estimates at different times. Costs can decrease over time because of downsizing, but more likely as a result of the learned efficiencies derived from production experience and/or economies of scale. This process is often represented by a learning curve, which depicts a gradual reduction in production costs over time. Thus, if no new safety technologies are introduced and a higher percentage of the fleet doesn't get an existing safety technology, then costs would come down as a result of the learning curve. Costs decrease from 1976 to 1985 for passenger cars and in a variety of other years for both passenger cars and LTVs. Most of the time when costs decrease over just a year or so, it is due to the learning curve. The third factor is the introduction of new safety technologies into the fleet, which typically results in an increase in costs reflecting the phase-in schedule of the safety standard.

Several of the initial safety technologies were installed by all passenger car manufacturers before NHTSA published an NPRM in the Federal Register. These technologies are not included in the costs because there are no incremental costs associated with them. They include: windshield wiping and washing systems and dual master cylinder brakes. The one exception is lap belts, where several States required their installation. NHTSA has decided to call all lap belts attributable to safety standards (see discussion on this point later in the analysis). The safety technologies installed in passenger cars by MY 1968, including voluntarily supplied and those attributable to the initial FMVSS that are counted in the analysis include: power boosters for brakes, side marker lamps, a glove box latch, seat back padding, front seat head restraints, energy absorbing steering assemblies, seat back locks, lap belts, and lap/shoulder belts at the front outboard seat positions. The MY 1968 voluntary and attributable incremental costs totaled $223.81 and 20.5 pounds for the average passenger car.

Many safety technologies were installed in LTVs later than in passenger cars, typically after they had been required in passenger cars but before the FMVSS were extended to LTVs. In MY 1968, voluntarily supplied and attributable safety equipment added $121.64 and 10.5 pounds to LTVs.

By MY 1976, passenger car voluntary and attributable cost had increased to $427.32 and weight to 73.3 pounds. Side door beams were installed in response to the original quasi-static crush requirement of FMVSS No. 214. A much larger percent of the fleet had power boosters for brakes and all front-outboard seats were equipped with head restraints. Seat belts were substantially upgraded: drivers and right-front passengers received integral 3-point belts with locking retractors. The increase in cost for LTVs ($227.35 and 24.7 pounds) was lower, as side door beams were not installed in LTVs.

Passenger car costs decreased from MY 1977 to MY 1985 as no major new FMVSS went into effect and the learning curve was reducing costs introduced in earlier years. LTV costs increased at a relatively slow pace until MY 1987, when rear wheel ABS was voluntarily added to about 16 percent of new LTVs. This increase in costs through MY 1986 resulted from extending passenger car standards to LTVs, including padded instrument panels, seat back padding, head restraints, collapsible steering columns, and fuel tank integrity.

Passenger car costs increased steadily from MY 1986 to MY 1989 before taking a big jump in MY 1990. During MY 1986 to MY 1989 there was an increasing percent of the fleet being voluntarily supplied with ABS, and during MY 1987 to MY 1990 the percentage of automatic belts increased, only to be phased-out by MY 1997.

The noticeable jumps in cost occurred in:

- MYs 1987 to 1990 with rear-wheel ABS for LTVs;
- MYs 1990 to 1994 with four-wheel ABS for passenger cars and MYs 1992 to 1996 for LTVs;
- MYs 1990 to 1995 with frontal air bags for passenger cars and MYs 1992 to 1998 for LTVs;
- MYs 2006 to 2008 with tire pressure monitoring systems for passenger cars and LTVs; and
- MYs 2007 to 2009 with side air bags for passenger cars and MYs 2007 to 2010 for LTVs.

By MY 2012 the voluntary and attributable cost for passenger cars had grown to $1,929.43 (in constant 2012 dollars) and the weight to 171.4 pounds. In LTVs the voluntary and attributable cost and weight of the FMVSS grew to $1,807.94 and 136.2 pounds as of MY 2012.

As a percentage of safety technology costs over the entire 1968-2012 time period, FMVSS attributable costs were (for most years) between 61 and 75 percent for passenger cars and averaged 70 percent. For LTVs the range was much larger (ranging from 23 to 85%) and the average was 55 percent (calculated by comparing column 6 to column 7 of Table 1a and 1b). This means that based on the methodology used in this analysis, vehicle manufacturers voluntarily would have spent 30 to 45 percent of the total costs to add safety countermeasures to vehicles. The average attributable weight compared to total weight for passenger cars was 75 percent and 62 percent for LTVs, both higher than the average percentage attributable for costs.

FEDERAL MOTOR VEHICLE SAFETY STANDARDS

SECTION 1 – BACKGROUND AND METHODOLOGY

The National Highway Traffic Safety Administration has a legislative mandate under Title 49 of the United States Code, Chapter 301, Motor Vehicle Safety, to issue Federal Motor Vehicle Safety Standards and Regulations to which manufacturers of motor vehicles and equipment must conform and certify compliance. Chapter 301 defines an FMVSS as a minimum standard for motor vehicle performance or motor vehicle equipment performance that is practicable, meets the need for motor vehicle safety, and provides objective criteria. The requirements are specified in such a manner "that the public is protected against unreasonable risk of crashes occurring as a result of the design, construction, or performance of motor vehicles and is also protected against unreasonable risk of death or injury in the event crashes do occur."

NHTSA has a comprehensive program to evaluate existing motor vehicle regulations to determine their effectiveness, benefits, and costs. The program includes evaluation of the weight and initial consumer cost of components that have been modified or added to motor vehicles in order to comply with the performance requirements of existing regulations. Since the late 1970s, NHTSA has sponsored cost studies of automotive safety equipment, and contractors have performed detailed engineering teardown analyses to provide definitive cost and weight estimates of this equipment. Results from these various analyses have been scattered among many hard-copy contractor's reports, using different economic years and sometimes-inconsistent methods of averaging costs across models. These contractor reports are available to the public in NHTSA Docket No. 2011-0066.

The objective of this report, which supersedes a report published by NHTSA in 2004, is again to estimate the overall cost of the FMVSS and the cost of each standard with a uniform methodology, updating the results to MY 2012. In general, the process is to determine the percentage of passenger cars and the percentage of LTVs that had the technology installed in their vehicles in each model year, to determine the weight and cost of that technology, to apply a learning curve to the cost of the technology, and to determine the average weight and cost that each technology added to the average passenger car and the average LTV in each MY 1968 to 2012.

The percentage of the new passenger cars and new LTVs that are equipped with each technology are derived from a number of sources. Sometimes it is as simple as noting that every new vehicle was required to meet a NHTSA standard by a certain date and matching that model year date with sales. However, for most new standards issued since the 1980s NHTSA has set the effective date based on a phase-in schedule. For example, 25 percent of each manufacturer's production between September 1, 2000, and August 31, 2001, must meet the standard, 50 percent in year 2, etc. The phase-in schedule method was designed to reduce cost and engineering demands so that manufacturers did not have to redesign every model in their fleet at the same time. NHTSA required manufacturers to submit pre-model year data with projected sales by make-model to make sure that manufacturers planned to meet or exceed the phase-in schedule. Overall compliance was later checked with real sales data. Sometimes the percentage of new vehicles equipped with a new technology is based on compliance data supplied by automobile manufacturers to NHTSA. Sometimes the percentage of the fleet equipped with a new technology is based on data provided by Ward's automotive yearbooks (particularly the factory-installed equipment spreadsheets), other times (particularly when we are considering voluntarily supplied technology before the start of a phase-in effective date) it comes from examining information provided in the literature on every make-model and weighting that data by sales information. The percentage of the fleet that actually meets a standard may be based on a sample of vehicles that have been tested, or have been visually inspected. At times very little data exists on the percentage of vehicles supplied with a given technology when it is an optional feature on a vehicle. Here we may rely on data reported in crash investigations (mainly FARS) to help determine the percentage of the fleet for which a particular technology was supplied. We do our best to derive the most credible data for the percentage of the new vehicle fleet sold with the relevant technology.

Cost and weight data for the major components of the motor vehicle equipment were extracted from contractor and NHTSA reports. Care was taken to determine the economic year used for the cost data in each study. All cost data were converted to 2012 dollars using the gross domestic product implicit price deflator from the Bureau of Economic Analysis (see the discussion around Table 4 for the process of converting cost estimates from mostly older year's dollars to 2012 dollars). The report also describes what vehicle modifications were made in response to the various FMVSS and explains how the cost estimates were derived. In summary, the report estimates the incremental cost of meeting the FMVSS in passenger cars and LTVs, with the year-by-year breakdown of the cost and weight per passenger car and LTV from MY 1968 thru 2012.

The Cost of an FMVSS -

The report attempts to answer two questions:

1) What is the incremental consumer cost of safety that is linked to the FMVSS?
2) How much of that linked incremental consumer cost was attributable to the requirements, as compared to safety that was installed voluntarily by automobile manufacturers?

Both of these questions are analyzed on a per vehicle basis (passenger cars separated from LTVs) and for every model year from MY 1968 to MY 2012. At the same time we estimate how much weight has been added to the vehicle for safety countermeasures in answering both questions.

In order to answer these questions, several definitions and assumptions are necessary, including what is included and what is not included in the analysis.

What is included: NHTSA has cost teardown studies of almost all of its FMVSS that estimate the retail price equivalent consumer cost of safety countermeasures that are linked to an FMVSS. Only incremental costs are included over a baseline.

What is not included: (1) Safety countermeasures that were standard equipment in 100 percent of vehicles before an NPRM was published are not included in the summary tables of this analysis. If a standard essentially did not change vehicles (i.e., if the equipment was already in place well before an NPRM and the standard essentially mandated what had already long been there), this standard does not add cost to the vehicle, and the cost of the equipment that was already there will not be attributed to the FMVSS and will not be considered as voluntarily provided before the NPRM. The weight and cost of the countermeasures may be discussed in the analysis, but they won't be included in the summary tables. For example, every passenger vehicle that came under FMVSS No. 103 had already been equipped with a windshield defrosting and defogging system long before NHTSA proposed such a requirement in an NPRM; nor is there any evidence that these systems were upgraded to meet the standard. No voluntary or attributable cost is assigned to FMVSS No. 103. Thus, the cost of basic safety features like brakes, lights, turn signals, the horn, etc. that were standard on every vehicle before NHTSA started rulemaking are not included in this analysis. (2) NHTSA has not estimated changes made to the basic frame of a motor vehicle to improve its safety in frontal dynamic crash tests. (3) NHTSA has not estimated the cost of safety items like blind spot detection or lane departure warning systems that are not linked to an FMVSS.

What definitions are needed – basic definitions are needed to determine what safety countermeasures are linked to an FMVSS and what is the appropriate baseline from which to determine incremental costs.

What assumptions are needed: Because NHTSA does not know why manufacturers installed safety equipment before the effective date of a final rule, a rule-of-thumb must be established to determine the baseline and when the installation can be considered "attributable" to a rulemaking proceeding and when the installation is considered "voluntary."

Further discussion of these definitions and assumptions follows.

Linked to an FMVSS –
We only count safety countermeasures that are linked to an FMVSS. There are two ways that a safety countermeasure could be linked to an FMVSS. First, NHTSA proposed it or proposed a performance standard that resulted in the safety countermeasure being used to meet a future standard. The proposal does not have to be a final rule at the time the countermeasure is installed. Second, even if it hasn't been proposed, NHTSA evaluated a safety countermeasure and found it to be effective at reducing fatalities, injuries or crashes. Since NHTSA writes mostly performance standards and not necessarily design standards, some safety countermeasures, never actually proposed and possibly never actually discussed in an NPRM, are used to help meet a standard or enhance the safety of other equipment used to meet a standard.

Example 1: NHTSA has never proposed seat belt pretensioners or load limiters, per se. However, those countermeasures enhance the safety of seat belts. Furthermore, those countermeasures have been evaluated and proven to have benefits in meeting FMVSS No. 208 and NHTSA has performed a cost teardown study on those systems. Pretensioners and load limiters have been included in this analysis as voluntary.

Example 2: NHTSA has never proposed rear window defogging and defrosting systems. NHTSA's evaluation was unable to conclude that rear-window defoggers reduce police-reported crashes. Thus, rear-window defoggers are not linked to an FMVSS because they have never been proposed and NHTSA has not proven safety benefits. The cost of rear window defoggers and defrosters are not included in this analysis.

Example 3: Intermittent windshield wipers are related to FMVSS No. 104, Windshield wiping and washing systems. However, they have never been proposed by NHTSA and have never been evaluated by NHTSA, and by our definition are not linked to an FMVSS.

Voluntary
Voluntary costs are assumed at two different times in relation to the baseline. First, voluntary costs can occur before an NPRM (on or before the baseline year). The voluntary cost of safety technologies installed by manufacturers includes safety modifications that took place in model years before an NPRM and are linked to an FMVSS. In order to be considered voluntary, these safety countermeasures had to provide some level of safety and not necessarily meet every aspect of the future FMVSS. In the discussion of each standard we will identify the attributable costs as well as the voluntary costs.

Second, voluntary compliance after the baseline year is assumed to be the same as the compliance during the baseline year. Thus, if the baseline year is MY 1999, voluntary compliance for MYs 2000 to MY 2012 is assumed to be the same as in the baseline year of MY 1999. In other words, we assume that without the rulemaking voluntary compliance would have stayed at the same level as it was in the baseline year for all years through MY 2012.

Attributable to an FMVSS
The attributable cost of an FMVSS in this report includes the incremental cost of all equipment or specific safety technologies added or modified primarily for the purpose of meeting (or even exceeding) the requirements of the standard over and above the voluntary compliance, provided these modifications took place after the baseline year. Essentially, if it is an incremental cost over the voluntary compliance level linked to an FMVSS that occurs after the baseline year, then it is attributable to the FMVSS.

The Appropriate Baseline Year
The build up to a final rule (which can include possible Congressional action, possible advance notice of proposed rulemaking, NPRM, possible supplemental notice of proposed rulemaking, final rule, possible petitions for reconsideration, possible amended final rule) is different for almost every rulemaking. When manufacturers decide to install safety equipment prior to its requirement as a standard, their intent is difficult to determine. They may be installing it to voluntarily provide added safety, a selling point that is an advantage in the marketplace. Alternately, they may be doing it in anticipation of possible forthcoming regulation, determining that their redesign cycle for specific models dictates current rather than future redesign efforts. It is thus difficult to make subjective judgments regarding manufacturers' intent until such time as NHTSA's intent to regulate is made apparent through the formal rulemaking process. This difficulty can be seen in the diverse scenarios that precede the publication of a final rule. For example, the circumstances can include: there was an Act of Congress requiring a specific action by a specific date; there was an Act of Congress requiring NHTSA to examine a specific safety problem and solve it, but Congress did not specify a specific countermeasure; there was an FMVSS requiring passenger cars to meet a standard, but the final rule for LTVs occurred many

years later; there were occasions when there were many years between an NPRM and the final amended final rule; there were occasions when there were years of NHTSA and others research on the subject; there were occasions when there were years of safety countermeasures supplied voluntarily by different manufacturers; in some cases NHTSA planning documents identified upcoming rulemakings, etc. In order to not have to make a subjective decision for every rulemaking, we developed a rule of thumb to determine not only an appropriate baseline, but also when a safety countermeasure was voluntarily provided and when it was attributable to an FMVSS.

We could have chosen the effective dates as required by the FMVSS. However, that would underestimate the real attributable cost of the FMVSS for years leading up to the effective dates. We know that manufacturers try to design anticipated safety requirements into their vehicles as their new models are being redesigned to save the cost of retrofitting existing models in the future. We know that manufacturers don't have the capability to redesign and test all of their make/models in one model year and that is why we have phased-in effective dates. Choosing the effective dates as the attributable dates would mean that every safety measure introduced before the effective date would be considered voluntary compliance. Since redesign cycles often dictate the timing of vehicle safety designs changes, choosing the effective dates did not seem appropriate. The goal is to get our best estimate of the cost of the FMVSS for each year, and also to recognize that the manufacturers often voluntarily provided safety features as part of their marketing strategy or safety strategy.

We wanted to designate a rule of thumb, so that we could consistently assign a baseline year and be able to distinguish between voluntary costs and attributable costs, without having to make a subjective decision for each rulemaking. The one consistent identifiable date for every rulemaking is the NPRM. The NPRM signals the real start of a rulemaking, with an identifiable test procedure and draft language. It seems logical to use the NPRM date to help define the baseline year. Typically, NHTSA has considered September 1 as the start of a new model year. We decided to choose the last model year in production as of September 1 before the publication of an NPRM in the Federal Register as the baseline date. In some cases, like TPMS, there were starts and stops to the rulemaking process and more than one NPRM was published. In this case, we apply the baseline year to the first NPRM on the subject. We recognize that this rule may not be precise for every safety technology, but we believe it will be a reasonably accurate basis for assigning attribution to most FMVSS.

All model year vehicles meeting the final rule on or before the first September 1 before an NPRM would be considered voluntary. For example, if an NPRM were published in the Federal Register in October 2000, the baseline date would be set at September 1, 2000 (MY 2001). Similarly, if an NPRM were published in the Federal Register in August 2001, the baseline date would be set at September 1, 2000 (MY 2001). All complying vehicles with the final rule (or in some cases parts of the final rule) in MY 2001 and earlier would be considered voluntary costs. Voluntary compliance for MYs 2002 to MY 2012 is assumed to be at the same level as compliance in the baseline year of MY 2001. For all model year vehicles starting after the baseline year (MY 2002 in our example) the difference between complying vehicles in that model year and the voluntary assumption for the baseline year of MY 2001 would be considered attributable to the final rule. For example, if 30 percent of passenger cars met a standard in MY

2001 (the baseline year), 50 percent of passenger cars met the standard in MY 2002 and 100 percent of passenger cars met the standard in MY 2003, the assumptions would be as follows:

	MY 2001	MY 2002	MY 2003 and later
Percent Complying	30%	50%	100%
Voluntary	30%	30%	30%
Attributable		20%	70%

We have made one exception to the rules for attributable and voluntary set out above. The only exceptions to these rules are lap belts, which were required by several States before NHTSA was established. Lap belts are considered attributable to safety standards, even though those standards were not strictly FMVSS (but State standards). See the discussion under FMVSS No. 208.

Incremental Costs – Other Notes

If every make/model (100%) meets the criteria by the baseline date and there is an indication that some things changed after the standard was effective that could be linked to the standard, then there is an incremental cost between the new cost and the baseline cost. It is possible that some manufacturers wanted to improve the performance of their countermeasure above the level of the standard. If some make/models meet the standard and others do not before the baseline date, then we assume there are incremental costs that fall into either the voluntary or attributable costs as discussed above.

This decision can be bifurcated by vehicle type. For example: for the sliding door requirements of FMVSS No. 206, every full size van met the standard long before the rulemaking process began and no full size vans were changed as a result of the standard. Thus, no incremental costs are attributable to full size vans, nor are any voluntary costs assigned. On the other hand, some minivans met the standard before the baseline date and others did not. Incremental costs are attributed to those that met the standard and are considered voluntary up to the baseline date and are considered either voluntary or attributable on or after the rule of thumb date, as discussed in the table above.

For some FMVSS there is an entirely new type of equipment provided and in these cases the incremental cost is the total cost of the added safety equipment. For example, the center high mounted stop lamp was an added-on device and little, if any, change was made to any other part of the vehicle to accommodate the lamp.

For some of the performance standards there is no easily identifiable countermeasure like an air bag or head restraint. For example, it is not easy to determine whether passenger cars that met the FMVSS No. 216a roof crush upgrade earlier than the NPRM voluntarily spent money on roof crush or whether this was due to the basic design of the vehicle. In addition, it is impossible to know what the incremental cost for roof crush would have been compared to an unknown design that would not have complied with the NPRM. Thus, we have not assumed incremental costs and we have not assumed that manufacturers that meet the upgraded test requirements of FMVSS No. 216a earlier than the NPRM have voluntarily spent money on safety before the requirements. There is a similar situation with FMVSS No. 301R (301R is the revised MY 2007 rear impact test for FMVSS No. 301). There is no easily identifiable countermeasure, making it difficult to determine what percent of the fleet voluntarily met a standard without test results. Thus, we assume no voluntary compliance for FMVSS No. 301R.

We have only estimated costs of FMVSS that have permanent costs. If an FMVSS causes redesign costs for a few model years, but ultimately does not result in any new equipment, we have not estimated a cost. For example, the requirements of FMVSS No. 101 resulted in simply relocating and changing the visual appearance of the controls and displays. The engineering labor to redesign these controls and displays is not considered a permanent cost and is not included in this analysis.

This report is limited to initial consumer costs of FMVSS, i.e., the likely effect of the FMVSS on the initial purchase price of a vehicle. Lifetime costs for maintaining or, when necessary, replacing components are not included; however, on an average vehicle basis, these costs tend to be negligible for most FMVSS. The notable exceptions, where maintenance costs may not be negligible are tire pressure monitoring systems (because batteries used in the direct system tire monitors won't last forever) and possibly frontal air bags (because of replacements or air bags and supporting structures after crashes). Not all crashes resulting in air bags being deployed result in additional maintenance costs. Many frontal air bag deployments, more side air bag deployments and most rollover crashes result in the vehicle being totaled and the air bags not being replaced.

The cost of an FMVSS may change over time, as a result of more efficient design, a more efficient production process, new types of materials, or vehicle downsizing (if the weight of the equipment is proportional to the weight of the vehicle). For example, head restraints became less expensive due to more efficient design, and side door beams due to all of these factors, including vehicle downsizing. We are interested in tracking the costs over time. Sometimes we have more than one cost teardown study on the same technology and can track how costs have changed over time. But this occurs in only a few instances. We have chosen 5 of those instances to develop an estimate of the learning rate for motor vehicle safety technologies. This rate is applied to a standardized learning curve methodology to estimate how costs change over time. More discussion of how the learning curve is calculated will follow in a subsequent section. In this report, unlike the 2004 report, we estimate the effect of the learning curve on costs.

Presentation of Cost and Weight Data in this Analysis –
Since different readers could decide to make different choices about the baseline and what are voluntary versus attributable costs, we have provided the weights and costs using a four step process. First, we show the baseline costs as determined by our cost teardown studies or other NHTSA estimates converted to 2012 dollars for every NHTSA FMVSS for which we have data. Second, if we determine that these costs are linked to an FMVSS for passenger cars and/or LTVs, we show the percentage of each new model year's fleet that are equipped with the countermeasure. Third, we show the weights and costs after applying the learning curve for all model years in which the countermeasures were installed. These estimates are weighted by the percentage of the fleet that are equipped to determine average vehicle costs. Fourth, we apply the baseline, voluntary, and attributable definitions to those cost estimates. The executive summary

tables are a compilation of the tables after the fourth step that include the average weights and costs by model year and distributes them between voluntary and attributable.

Cost and Weight Analysis Methodology –
The teardown or reverse engineering methodology typically used by a NHTSA contractor for the collection of cost and weight data is described below.

- **Cost Study Sampling Plan**. An integrated cost sampling plan is developed to provide for the selection of a group of comparable makes and models that are representative of vehicle systems prior to and after the effective date of the standards. The plan is designed to identify a representative cross-section of vehicle sizes, models, and manufacturers, without the need to individually examine every make-model passenger vehicle produced in the affected years. Make-models of passenger vehicles are selected, and system components purchased, for cost analysis. These make-models should:

    - have over 50,000 annual sales volume
    - include matching pre- and post-standard vehicles of the same make-model (unless the FMVSS resulted strictly in add-on equipment, in which case it is only necessary to sample the post-standard vehicles)
    - represent the variety of designs or differences in the types of parts used to meet the FMVSS
    - represent the major domestic and import auto manufacturers
    - represent vehicle weights or sizes ranging from small to large
    - represent the vehicle types (passenger car, SUV, van, or pickup truck)

- **Teardown Process**. The cost and weight estimates are based on detailed engineering analysis of the individual pieces and assemblies of which the system is composed, employing a process known as reverse engineering. Whereas conventional engineering proceeds from design to mass-produced product and proceeds back through the various manufacturing processes to the design, this procedure includes a step-by-step teardown or disassembly of each item into sub-assemblies and finally into individual component parts. The teardown sequence is the reverse of the assembly sequence. The components and parts are carefully cataloged and tagged as they are being disassembled. The parts are gauged, measured, manufacturing method determined, and, if possible, the vendor for outsourced parts identified. Even parts that were welded or irreversibly attached are carefully disassembled. The system components are physically torn down into their most elemental parts to identify the process operation by which each elemental part is made in terms of:

    - labor minutes,
    - direct materials and scrap,
    - machine occupancy hours or station times, and
    - machinery, equipment, and tooling used.

The components are laid out on a pegboard, with one-inch squares, and photographed next to appropriate identification labels so the photos can be compared with the cost estimates.

- **Technical Analysis**. The parts from the comparable vehicle systems are analyzed (in some contractor reports) to determine:
    - changes between the pre- and post-standard make-models, and
    - reasons for the changes, i.e., differentiate between changes for meeting the FMVSS and changes for unrelated reasons such as:
        - styling,
        - cost reduction, and
        - product improvement (functional improvements not related to the requirements of the FMVSS).

The net result of the analysis is the accurate and complete identification of all changes in the component parts of the selected systems that are attributable to the requirements of the specified FMVSS.

- **Cost Analysis**. Costs are determined by production decisions, whereas, prices are the results of marketing decisions based on an assessment of what the traffic will bear when faced with a competitive environment of substitutes. To arrive at a price that will pass in the trade, the vehicle manufacturer engages in a form of cost/price arbitrage across his entire model lineup. At the low end of the pricing scale, competition from other manufacturers may prevent a company from charging a price sufficient to cover the full cost of producing a vehicle line at planned volumes. However, the company can cover this shortfall in other market segments where competition is less intense by charging prices that, on a volume basis, generate sufficient margins to cover the full costs of a vehicle line plus a contribution to overall corporate overhead and profit that offsets the shortfall.

    In developing cost estimates for proposed and existing safety standards, all components identified in the technical analysis that changed because of the implementation of the FMVSS are cost analyzed to determine their consumer price. The cost comparison is performed in two stages. The first (micro-analysis) considers the elements of cost that vary from one part to another (variable costs), and the second (macro-analysis) considers those elements of cost that do not vary (fixed costs).

    - **Micro-analysis**. The micro-analysis consists of the teardown process itself and the identification of the following costs for each elemental part where applicable:
        - ***Variable Manufacturing Costs***
            - **Direct material cost** is estimated by judging the weight of the component in the rough state and multiplying that weight by its cost per pound factor appropriate to the material, gauge, grade, etc. Included in direct material cost, or as a separate line item, should be an allowance for scrap material as a result of the production

process. Most scrap can be sold or recycled, so the appropriate amount is a net cost for scrap per unit.

- **Direct labor costs** are determined by time and motion analysis of each labor input per cycle or operation. Each labor input or operation is timed in terms of labor minutes or fraction thereof. The hourly rate is divided by 60 minutes to obtain labor cost per minute. Labor cost is determined by multiplying labor minutes (usually a fraction) by labor cost per minute

- **Variable manufacturing burden**. This accounting classification includes all costs that vary directly with production volume but cannot be specifically attached to each unit of end product. Examples would include electric power, indirect labor such as materials handling, and perishable tools.

▪ ***Fixed Burden (Fixed Factory Overhead)***

- Depreciation per Unit (Allocated)
- Amortization of Special Tooling per Unit (Allocated)

Using prevailing labor and material costs, the variable manufacturing costs and total manufacturing costs for each elemental part, component, subassembly, and complete assemblies that constitute each system under study are determined. Specific cost elements that must be isolated and identified include the following.

▪ direct labor dollars per unit
▪ direct material costs and scrap allowances per unit
▪ variable burden cost per unit, including indirect labor and other costs that vary with production volume
▪ fixed burden per unit
▪ capital investments required at prevailing annual sales volumes – property, plant, equipment, and tooling
▪ depreciation schedules for property, plant, and equipment
▪ amortization schedules for special tooling

Cost estimation is performed using operation worksheets, which identify raw materials, labor, and machine utilization for each operation of the manufacturing process. The worksheets are used to record the component, subassembly, and assembly processing methods. A worksheet is prepared for each part and subassembly. The following items of information are collected on each operation worksheet.

▪ identifying numbers
▪ material type, gauge, quality, blank size
▪ finished weight

- rough weight
- percent scrap
- production volume
- tooling cost and amortization
- number of parts per safety system
- operations
- type of equipment pieces per hour
- number of machines
- made in-house or purchased

The manufacturing operations are determined, their operation numbers are listed, and the operations described on the worksheet. Various equipment stations in the manufacturing plan are associated with each operation. Their codes are listed, as well as the pieces per hour, for the equipment. Next the estimator must determine the number of machines required for the operation. There is an interaction between the number of people and the number of machines a person can operate. To determine the labor per part requires estimating this interaction. In addition to estimating the cost of individual parts, the cost of assembling parts into subassemblies and assemblies, where appropriate, is developed by determining the operations necessary to achieve the assemblies. The variable cost includes only those costs associated with the manufacture of the part or assembly, i.e., direct labor and direct material costs associated with making the part or assembly. Also included in the variable cost is the variable burden, which includes such things as set-up costs, inbound freight, perishable production tools, and other miscellaneous costs that vary with production volume changes.

- **Macro-analysis**. The macro-analysis develops the pricing template used to derive the estimated retail price impact of safety requirements imposed by NHTSA. The teardown process described above does not isolate all of the elements that must be accounted for in order to arrive at a price that covers full cost plus profit margin. Discretionary costs such as selling, general, and administration; research and development; taxes other than income; pension expense; and plant maintenance and repair must be allocated to each unit of product. Furthermore, after covering discretionary costs, there should be sufficient residual for income taxes and a bottom line net profit.[2]

[2] Spinney, B. C. (1989, February). *Development of markup rates for regulatory cost analysis that approximate industry pricing practices*. Washington, DC: National Highway Traffic Safety Administration. Also see Spinney, B. C., Faigin, B. M., Bowie, N. N, & Kratzke, S. R. *Advanced Air Bag Systems Cost, Weight, and Lead Time Analysis Summary Report*, Contract No. DTNH22-96-0-12003, Task Orders – 001, 003, and 005, Docket No. NHTSA-2007-27453-10.

Accounting Basis for the Macro-Analysis -
Over the last 40 years, NHTSA has developed and refined a technique for approximating the pricing structure of automotive manufacturers. This technique involves the derivation of markup factors from financial analysis of company income statements and consists of isolating the major corporate cost and expense accounts and rearranging them according to a template that reflects cost behavior rather than Generally Accepted Accounting Principles (GAAP). Under the behavioral approach, costs and expenses are defined as variable, fixed, or discretionary.

Variable costs (or variable manufacturing costs) are defined as costs that are constant per unit of input but vary directly in total with changes in production volume. Direct labor, direct material, and variable burden all fit this definition. Fixed costs are constant in total regardless of volume. The only true fixed costs are depreciation and amortization. Most factory and corporate overhead accounts costs have a fixed component and a variable component that can increase or decrease at management's discretion—hence the name discretionary costs.

Variable manufacturing costs are engineered into the production process and cannot be changed to an appreciable degree on a per unit basis at planned production volumes. On the other hand, fixed costs and discretionary costs can be allocated on a per unit basis according to a rationale of management's choosing. It is this allocation process that establishes the pricing structure of the company. In order to approximate this allocation process, variable costs must be isolated to the degree possible from fixed and discretionary costs.

Income statements prepared according to GAAP do not segregate cost and expense accounts based on behavior. The Cost of Sales account, for example, includes both variable and discretionary costs. In order to approximate the cost/price arbitrage process, the variable manufacturing costs must be segregated from fixed and discretionary costs. Through analysis of Form 10-K Corporate Annual Reports filed annually with the Securities Exchange Commission by domestic manufacturers, NHTSA has isolated three discretionary cost accounts to be subtracted from Costs of Sales.

- Maintenance and Repairs
- Research and Development
- Taxes Other Than Income

Upon subtraction, the three accounts are reclassified under the general head of Fixed/Discretionary Costs. The remainder of Costs of Sales constitutes estimated Variable Manufacturing Costs.

Each manufacturer's income statement is reformatted according to this methodology and the process is called common sizing. The result is a template that enables the analyst to study a company's cost structure and compare it against competitors. The completed template is shown below in Table 3:

Table 3

SAMPLE COST/PRICE CORPORATE TEMPLATE
(Manufacturing Operations Exclusive of Financing Subsidiaries)

Net Sales	$100,000,000	100.0%
Variable Manufacturing Costs	74,000,000	74.0%
Contribution Margin	$ 26,000,000	26.0%
Fixed/Discretionary Costs:		
Maintenance and Repairs	$ 3,500,000	3.5%
Research and Development	3,000,000	3.0%
Taxes other than Income	2,000,000	2.0%
Selling, General, & Administration	7,000,000	7.0%
Pension Costs	2,000,000	2.0%
Depreciation	3,500,000	3.5%
Amortization of Special Tooling	2,500,000	2.5%
Amortization of Intangibles	500,000	0.5%
Total Fixed/Discretionary Costs	$ 24,000.000	24.0%
Income from Continuing Operations	$ 2,000,000	2.0%
Other Income (Expense)-Net	1,000,000	1.0%
Income before Interest and Taxes	$ 3,000.000	3.0%
Interest Income (Expense)-Net	(500,000)	0.5%
Income before Income Taxes	$ 2,500,000	2.5%
Income Tax Expense (Credit)	875,000	0.9%
Net Income	$ 1,625,000	1.6%

(Note: The dollar amounts are hypothetical; however, the percentages of sales for each account reflect long-run weighted averages of the Big Three)

The key to NHTSA's pricing template lies in the relationship between net sales, variable costs, and contribution margin. Net sales represent total wholesale revenue less returns and allowances. Variable costs have been defined above and account for 74% of net sales. The contribution margin rate of 26% on sales represents the remainder left for fixed/discretionary cost coverage. Since the template reflects company-wide operations, by definition it reflects the fixed/discretionary cost/price recovery arbitrage process across all product lines whereby a manufacturer meets its profit objectives at expected volumes.

Thus, the pricing formula used by NHTSA to approximate wholesale price for a new safety feature only includes variable costs, which are determined by detailed analysis of the production process, and a markup percentage on variable costs equal to the corporate wide contribution margin rate. If variable costs account for 74% of sales and contribution margin accounts for 26%, then the markup factor on variable costs to wholesale price would be 1.35 (100% / 74%). Over the years this markup factor has changed little, generally being in the range of 1.35 to 1.36. Most of the cost teardown studies use the 1.36 markup factor.

To arrive at the manufacturer suggested retail price (MSRP), wholesale price needs to be marked up to cover the dealer margin. Currently and historically, dealer margin is about 11% on wholesale on a fleet-wide weighted average basis. The completed pricing formula is:

Variable costs * 1.36 * 1.11 **OR** Variable costs * 1.51

In 2012, during the process of setting the final rule for MY 2017-2025 passenger car and LTV fuel economy, NHTSA and EPA reviewed this macro analysis process for setting the Retail Price Equivalent (RPE) value of 1.50. Their findings were: However, an analysis of historical RPE data (1972-1997 and 2007) indicates that although there is year to year variation, the average RPE has remained at approximately 1.50.[3]

Inconsistencies and Variations in Contractors' Approaches to Estimating the Cost and Weight of an FMVSS -

Over the years that NHTSA and its contractors have been performing cost and weight analyses, the contractors' reports have not necessarily used a consistent methodology to select vehicles for analysis, to determine which parts of the vehicle truly were changed due to the standard or to sales-weight the results. There are a variety of legitimate reasons for these results. The main reason is that until the contractor performs the pre and post standard analysis, you may not know which parts were changed due to the standard and which ones were not. But the contractor reports on what his tasks were, what vehicles and parts were cost-estimated, etc. After the findings have been analyzed and interpreted, you can come to a better understanding of the impact of the standards. In this analysis, we attempt to correct for this later knowledge and develop our best estimate of the impact of the standards. Thus, the contractor's studies provide information used in this report, but the contractor's reports themselves should not be considered the best estimate of the overall average cost of the standard. We now discuss, in general, issues we have found with various contractor reports, which indicate why some of the contractor's studies cannot be used for this report without interpretation by NHTSA.

- **Selection of Vehicles/Definition of Effect of the FMVSS**
    - The contractor tore down pre-, as well as, post-standard vehicles. Costs attributed to the standard are allocated based on the following criteria:
        - Without further analysis, the contractor attributed the entire difference in the cost and weight of the pre- and post-standard subsystems to the standard. For example, with FMVSS No. 216, some motor vehicles were redesigned in the year the standard took effect. The cost of styling-related changes was included in the cost of the teardown study, but should not have been.

[3] NHTSA.(2012, August). *Final Regulatory Impact Analysis, Corporate Average Fuel Economy for MY 2017-2025 Passenger Cars and LTVs.* Washington, DC: In Docket No. NHTSA-2010-0131-0417, Page 771 and 785. The fuel economy analysis also discusses a different macro methodology known as the indirect cost multiplier (ICM). NHTSA has chosen the RPE method for analyzing its safety standards.

- Only part of the difference is attributed to the standard, while the rest of the difference is attributed to styling, product improvement, or other factors unrelated to the FMVSS. For example, with the original 1968 version of FMVSS No. 201, a comparison of various interior structures in pre- and post-standard passenger cars indicated that costs in some structures might be consistently higher for the post-standard specimens, which probably indicates they were modified because of the standard. However, costs in other structures went up in some specimens and down in others, which indicates the modifications were merely for styling or production efficiency and not needed for meeting the standard.

- The contractor only performed the physical teardown of post-standard vehicles' subsystems believed to be affected by an FMVSS. This approach works best for a standard that added on an entire subsystem, with no other change in pre-existing equipment on other subsystems. However, contractors have also used this approach on other occasions, such as when contract funding was insufficient to study pre-standard vehicles. Costs attributed to the standard are allocated based on the criteria listed below:

  - The full cost of the new equipment is attributed to the FMVSS, because the cost in the pre-standard vehicle is zero. For example, with No. 108, center high mounted stop lamps were added as standard equipment in MY 1986 to reduce rear-impact crashes, but did not result in changes to any other rear lighting system.

  - The contractor does not attribute the full cost of the equipment to the FMVSS, because the contractor asserts or assumes that some of this equipment either already existed in the pre-standard vehicle (although no such vehicles were torn down) or was not added because of the FMVSS, but for some other reason. For example, with the FMVSS No. 214 upgrade dynamic test requirement, some of the components partially contributed to both pre- and post-revision requirements of FMVSS No. 214. The contractor used engineering evaluation and judgment to assign a percentage of the identified costs as a contribution towards the additional requirements imposed by the revised standard. NHTSA may agree or disagree with the contractor's judgment in these cases.

  - The contractor limited the teardowns to post-standard vehicles, even though the equipment was not strictly an add-on, and did not even discuss what parts were there before the standard was implemented, or if the new equipment was safety related. For example, with FMVSS No. 201, a study of the interior components of 1982 model year trucks was conducted to determine the impact of the standard on LTVs. No pre-standard make-models were studied to serve as a baseline. Since some of the make-models were extensively redesigned in 1982, the contractor was unable to directly compare the components of the pre- and post-standard LTVs and did not estimate the average cost increase.

- **Teardown Sample Selection**. Some contractors selected a sample of motor vehicles too small to make a meaningful sales-weighted average. Ideally, to calculate a sales-weighted average, six or more vehicles should be in the sample selection; otherwise, an arithmetic average will be calculated on five vehicles or less. In addition, even a larger sample size can be too small if it does not adequately represent a cross-section of vehicle sizes, body styles, and manufacturers. For example, with FMVSS No. 214, an analysis of the impact of the dynamic requirements on 2-door passenger cars was conducted on only two import cars representing the compact and midsize categories.

- **Definition of Pre- and Post-FMVSS**. Some contractor reports used the model year immediately before the FMVSS as the pre-standard model year. Their rationale was that if manufacturers complied with the standard in that year, their modifications were voluntary and should not be attributed to the standard. Other contractors used a model year several years before the standard as the pre-standard model year. Again, NHTSA might have to make adjustments by eliminating some vehicles from the study, because they were changed pre-standard to meet the standard.

Methods Used in This Report to Make the Estimates More Uniform -

- **Criteria for Averaging Costs Across the Make-Models in the Teardown Sample**

    - If the teardown sample is reasonably large (six or more vehicles) and reasonably representative of the vehicles on the road, we will use only sales-weighted averaging. Otherwise, we will take a simple arithmetic average of the costs in the teardown sample.

    - A sales-weighted average for the cost and weight figures of the make-models studied is calculated to provide a more accurate representation of the average price differentials. This is accomplished by multiplying the cost and weight figures of each make-model by a weight relevant to its importance, adding the results, and dividing the total by the sum of the weights. The weight in this instance is the volume figures based on the new passenger vehicle registrations for each make-model studied. The volume figures for the MYs 1965-1974 were obtained from Ward's Automotive Yearbook[4] and the volume figures for the 1975-2001 model year on up were obtained from the R.L. Polk National Vehicle Population Profile.[5] Most of the 2002-2012 volume figures used in sales weighting are from Ward's Automotive Yearbook.

    - If we can reasonably expect the same type of equipment in two make-models of similar design with different names (e.g., Ford Taurus and Mercury Sable), we

[4] Ward's Automotive Yearbook. (Annual Publication). Detroit: Ward's Communications.
[5] National Vehicle Population Profile. (Annual Publication). Detroit: R.L. Polk & Company.

will do sales-weighted averaging by fundamental car groups. This method was used for the FMVSS No. 214 side door beams.

Fundamental car/truck groups are composed of passenger vehicles that have the same automotive manufacturer, belong to the same functional class, and have the same wheelbase. NHTSA staff has defined the fundamental car/truck groups, and have used these classifications in several evaluation reports. The criterion to use the fundamental car/truck group for the volume figures is based on the premise that the make-models from the same manufacturer use common structure and mechanisms for all make-models sharing a common body size. However, these vehicles are not necessarily identical except for the nameplate and may vary to some extent in weight or appearance.

- If the equipment, however, might not be the same because it is tied into the appearance of the vehicle or for others reasons (consumer preference, vehicle manufacturer design choices), we will sales-weight by sales for the specific make-model in the teardown sample. For example, with FMVSS No. 202, vehicle manufacturers installed adjustable or nonadjustable (integral or fixed) head restraints in response to the standard and did not necessarily install the same head restraints in different make-models belonging to the same fundamental car group.

- If the contractor has looked at a number of pre- and post-standard vehicles, we will take a sales-weighted average of only the make-models where there are matching pre- and post-standard vehicles. We will then weight the difference between the pre- and post-standard costs in each of these matched pairs by the sales of the post-standard vehicles. If we can't do all of this, we will just take the simple arithmetic averages, otherwise we run the risk of getting spurious costs due to shifts in the sales mix.

- In general, if the contractor has looked at pre- and post-standard vehicles, we will take the incremental cost difference between the two. However, there are certain cases where this gives too low an estimate, because even the equipment in the pre-standard vehicle was added after the rulemaking process began. In those cases, we will use the full cost of the equipment in the post-standard vehicles like we did for FMVSS No. 214 side door beams in LTVs.

- **FMVSS Modifications Versus Redesigns Unrelated to FMVSS**

  - If the contractor has attributed to the FMVSS costs that are plainly due to other redesign reasons, we will deduct those costs if that is simple to do. For example, with FMVSS No. 214, changes in the body pillars of 1973 make-model passenger cars were a result of model redesign and not directly related to the standard; therefore, the weight and consumer cost for them were not included in the side door strength calculations.

- If there is no simple way to do it, we may limit ourselves to the make-models in the contractor's sample that we know were not redesigned in the year the FMVSS went into effect. For example, by singling out only the pre- and post-standard FMVSS No. 216 make-models that did not receive any overall redesign, it is plausible that any changes were specifically due to the standard.

- **Linear Interpolation When Weights Change Over Time**. If we have two weight estimates for the standard, i.e., 10 pounds in 1980 and 5 pounds in 1990; and, unless we have additional information that pinpoints the time of the weight reduction, we will assume a standard weight of 10 pounds each year until 1980, a declining linear rate (in this case, 0.5 pounds per year) from 1980 to 1990, and then a weight of 5 pounds each year from 1990 onward.

- **Adjusting for Inflation**: The labor and material rates used by contractors to estimate the costs were compiled from publicly available sources such as the U.S. Department of Labor, Bureau of Labor (under Employment, Hours, and Earning), and from union contracts. Material costs were determined from the contemporary market price for the appropriate material. These costs are based on U.S. automotive (Detroit, Michigan area) manufacturing practices, labor rates, material costs, and tooling/equipment costs. This information is publicly available in the Commodity Research Bureau (CRB) Commodities Yearbook as well as automotive union contracts. The labor and material rates were updated periodically, and each cost study was based on a given economic year.

  In this report, all cost data have been converted to 2012 dollars. Even though a particular standard may have been studied in an earlier economic year, using the gross domestic product implicit price deflator adjustments can bring the original cost data to 2012 economics. For example, the first contractor's teardown study done for NHTSA was in 1978 economics. The implicit price deflator for 1978 is 37.643 and 105.002 for 2012. To bring the 1978 data to 2012 economics, the original cost estimates are multiplied by the factor of 105.002/37.643 (the ratio of the implicit price deflator for 2012 relative to that of 1978).[6] The indexes for 1976-2014 are listed on Table 4.

  NOTE: When we discuss particular cost teardown studies or other data, all of the costs will be converted to 2012 economics ($2012). The learning curve is then applied to estimate the change in costs from the year it was evaluated up through MY 2012, based on cumulative sales over that timeframe.

[6] Bureau of Economic Analysis. (Last updated March 27, 2014). Retrieved from the BEA website at www.bea.gov. Table 1.1.9, Implicit Price Deflators for Gross Domestic Product.

Table 4 GROSS DOMESTIC PRODUCT IMPLICIT PRICE DEFLATOR (2009 BASE)	
YEAR	**PRICE DEFLATOR**
1976	33.119
1977	35.173
1978	37.643
1979	40.750
1980	44.425
1981	48.572
1982	51.586
1983	53.623
1984	55.525
1985	57.302
1986	58.458
1987	59.949
1988	62.048
1989	64.460
1990	66.845
1991	69.069
1992	70.644
1993	72.325
1994	73.865
1995	75.406
1996	76.783
1997	78.096
1998	78.944
1999	80.071
2000	81.891
2001	83.766
2002	85.054
2003	86.754
2004	89.132
2005	91.991
2006	94.818
2007	97.335
2008	99.236
2009	100.000
2010	101.211
2011	103.199
2012	105.002
2013	106.588
2014	108.686

- **Adjusting for the Learning Curve Effect:** The cost of products goes down over time as companies learn how to make the products more efficiently, and as their production volumes increase. As manufacturers gain experience through production, they refine production techniques, raw materials, component sources, and assembly methods to maximize efficiency and reduce production costs. Typically, learning curves reflect initial learning rates that are relatively high, followed by slower learning as the easier improvements are made and production efficiency peaks. This eventually produces an asymptotic shape to the learning curve.

To properly estimate the impact of learning under a cumulative volume approach, five things are required:

1. A progress rate representing the remaining portion of the price after each doubling of cumulative volume.
2. The direct cost of the technology at time n1
3. An estimate of the cumulative production volume for the specific technology at time n1
4. The direct cost of the technology at time n2
5. A history of the production of the technology between time n1 and n2

In an effort to explore the potential impacts of a learning curve, NHTSA has examined the cost and production changes for several safety technologies. NHTSA routinely performs teardown studies of the costs of safety technologies and in 5 cases we have cost teardown data developed to support a rulemaking as well as about 5 years later to evaluate the impacts of the regulation.[7] These data, together with actual production data, supply 4 of the 5 items needed above and this allows us to derive a progress rate specific to each technology.

The technologies examined were driver air bags, antilock braking systems,[8] 3-point manual outboard lap/shoulder belts with retractors,[9] dual master brake cylinders, and adjustable head restraints. The derived progress rate for each technology is shown in Table 5. The average progress rate for these 5 technologies is 0.93 and the average learning rate for a doubling of volume is 7 percent. In this report, the progress rate of 0.93 is used for all technologies except those with different rates in Table 5. All manual belts, whether they be front seat or rear seat, outboard seats or center seats, lap belts or lap/shoulder belts, and pretensioners, load limiters or adjustable anchor, use the 0.96 progress rate. All head restraints, whether they be front seat or rear seat, adjustable or integral use the 0.91 progress rate.

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[7] NHTSA also has cost data on energy absorbing steering columns (FMVSS Nos. 203 and 204) from two different times. However, the technology changed fairly dramatically between the two times and costs went up slightly. Given the changes in technology, it didn't seem appropriate to include it with the other technologies in the learning curve calculations.

[8] For this analysis, rear-wheel and four-wheel antilock braking systems were combined since they use the same components and learning would have occurred. In a previous NHTSA analysis, only four-wheel antilock brake systems were considered with a progress rate of 0.895. Averaging the 5 technologies in both cases resulted in rounding the progress rate results to 0.93.

[9] NHTSA has cost data on a variety of lap belt systems also. These were examined to estimate a progress rate with the following results: manual lap belt front center seat without retractors - 0.946, manual lap belt rear center seat without retractors - 0.913, manual lap belt rear seat outboard with retractors - cost went up in later years. Because these are based on only a few belt make/models, we do not want to claim precision for these estimates, and are using the 0.96 rate derived from outboard lap/shoulder belts with retractors, by far the most common type of belt system and the one for which we have the most robust cost data, for all belt related technologies.

Table 5
Progress Rate of Studied Technologies

Technology	Progress Rate	Learning Rate
Driver air bags	0.93	0.07
Antilock Braking Systems	0.87	0.13
Manual Lap/Shoulder Belts	0.96	0.04
Adjustable Head Restraints	0.91	0.09
Dual Master Brake Cylinders	0.95	0.05

Appendix A presents a sensitivity analysis of estimated costs using the range of progress rates calculated for Table 5. Appendix B presents important pieces of information used in the learning curve analysis.

In the analysis when there are two or more cost estimates for the same product over different time periods (for example, a cost estimate for four-wheel antilock brakes in MY 1989 to MY 1990 vehicles and a cost estimate for four-wheel antilock brakes in MY 2004 to MY 2006 vehicles) we have taken the latest cost estimate and its applicable time period (using the average MY 2005 vehicles) and used that in the learning curve equations. Our method calculates a higher estimated cost for years earlier than MY 2005 based on the learning curve going backwards and calculates lower costs for years after MY 2005, while pegging the exact estimate to MY 2005 vehicles. This method produces estimates that closely match the earlier (in this example MY 1989 to MY 1990) higher cost estimates since the progress rate was determined using both the earlier and later cost estimates.

We don't have a learning curve for weight, thus weight increases are held constant over time except for those instances where we have two or more different weight increases at different times. In those cases we used linear interpolation between the years for which we have weight data (MY 1989 to MY 1990 and MY 2004 to MY 2006 in our example) and held the MY 1989 weight the same for earlier years and the MY 2006 weight the same for later years.

For the learning curve calculations, calendar years sales were used from 1960 to 2012. These were the most consistent set of sales figures over the time period. Since many standards were effective in 1967-1968 and were being met by many manufacturers before that date, it was important to start counting production many years earlier. We chose 1960 as a starting point to count production toward the learning curve calculations. Table 6 shows the calendar year sales of passenger cars and LTVs used in the analysis.

An example of how the learning curve calculations work is discussed below. Upper interior head protection (FMVSS No. 201) in passenger cars is used as an example.

Step 1: Determine the cost of the technology (in 2012$) before the learning curve is derived. In this case it was $14.80.[10]

Step 2: Determine the average model year of the vehicles that were in the teardown study so that we know the teardown base year for cumulative production. In this case it was MY 2001.

Step 3: Determine the cumulative sales of vehicles with upper interior head protection by the teardown base year. We will also use the number of vehicles with upper interior head protection sold in future years in the calculations. For this we need a percent of the fleet with upper interior head protection for both passenger cars and LTVs multiplied by their respective sales in those years. Table 7 shows those results. The cumulative sales figures per year are used in the calculations. The cumulative volume in the teardown base year 2001 for FMVSS No. 201) is 18,012,382 vehicles sold.

[10] In theory learning only applies to the variable cost and should not be applied to consumer cost. However, given NHTSA's methodology of multiplying variable cost times 1.51 to derive consumer costs, and the fact that the learning curve is all multiplicative, it doesn't matter whether learning is applied before or after the 1.51 multiplier is applied. Thus, since you get the same answer with either methodology and to keep the analysis simpler and easier to follow, in this analysis learning is applied to consumer cost.

Table 6						
Calendar Year Passenger Car and LTV Sales						
(in millions of vehicles)						
Year	**Passenger Cars**	**LTVs**		**Year**	**Passenger Cars**	**LTVs**
1960	7.12	0.87		1987	10.28	4.95
1961	5.82	0.84		1988	10.54	4.92
1962	7.31	0.90		1989	9.78	4.76
1963	8.05	1.10		1990	9.30	4.57
1964	8.29	1.19		1991	8.18	4.14
1965	9.86	1.38		1992	8.21	4.66
1966	9.51	1.37		1993	8.52	5.38
1967	8.46	1.28		1994	8.99	6.07
1968	10.44	1.62		1995	8.62	6.11
1969	10.07	1.70		1996	8.48	6.62
1970	8.56	1.51		1997	8.22	6.90
1971	10.12	1.77		1998	8.08	7.46
1972	10.41	2.14		1999	8.64	8.26
1973	11.42	2.72		2000	8.78	8.57
1974	8.85	2.44		2001	8.35	8.77
1975	8.61	2.28		2002	8.04	8.77
1976	10.10	2.96		2003	7.56	9.08
1977	11.17	3.43		2004	7.48	9.38
1978	11.30	3.81		2005	7.66	9.29
1979	10.65	3.32		2006	7.76	8.74
1980	8.97	2.44		2007	7.56	8.53
1981	8.53	2.19		2008	6.77	6.43
1982	7.98	2.44		2009	5.40	5.00
1983	9.18	2.92		2010	5.64	5.92
1984	10.39	3.98		2011	6.09	6.65
1985	11.04	4.64		2012	7.24	7.20
1986	11.46	4.90				

Table 7 Example Calculation of Cumulative Sales For Learning Curve						
Year	**Passenger Cars Sales**	**LTVs Sales**	**Passenger Cars %**	**LTVs %**	**PC & LTV Annual Sales**	**PC & LTV Cumulative Sales**
1999	8.64	8.26	20.53	15.00	3,012,792	3,012,792
2000	8.78	8.57	47.54	28.22	6,592,466	9,605,258
2001	8.35	8.77	63.43	35.47	8,407,124	18,012,382
2002	8.04	8.77	71.55	75.60	12,382,740	30,395,122
2003	7.56	9.08	100	100	16,640,000	47,035,122
2004	7.48	9.38	100	100	16,860,000	63,895,122
2005	7.66	9.29	100	100	16,950,000	80,845,122
2006	7.76	8.74	100	100	16,500,000	97,345,122
2007	7.56	8.53	100	100	16,090,000	113,435,122
2008	6.77	6.43	100	100	13,200,000	126,635,122
2009	5.40	5.00	100	100	10,400,000	137,035,122
2010	5.64	5.92	100	100	11,560,000	148,595,122
2011	6.09	6.65	100	100	12,740,000	161,335,122
2012	7.24	7.20	100	100	14,440,000	175,775,122

Step 4: Determine -E, -E = the natural log of the progress rate divided by the natural log of 2. The progress rate for this technology is 0.93. So, –E = Ln(0.93)/Ln(2) = -0.105.

Step 5: Determine A, A = the natural log of the base price minus –E times the natural log of the teardown base year cumulative sales. A = Ln($14.80)-(-0.105)*Ln(18,102,382) = 4.443877.

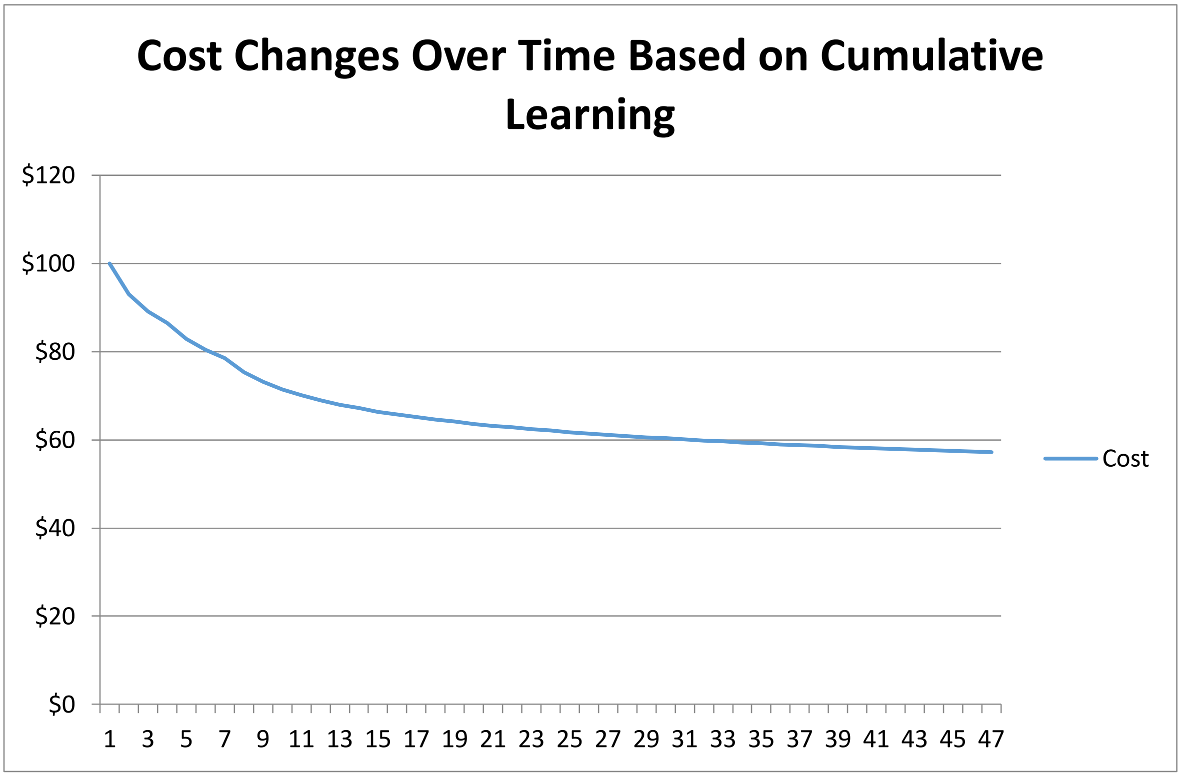
Step 6: To determine the cost of the technology per vehicle (C), for each year, you apply the formula C = EXP(A + -E*Ln(cumulative volume for that year). For 1999
C = EXP(4.443877+-1.05*Ln(3,012,792).

Step 7: Multiply the percentage of the fleet equipped with the technology by the learning curve cost to get the average price per passenger car. Table 8 shows the results. The base cost per vehicle ($14.80) is pegged to the teardown base year of 2001. Costs per vehicle are higher in preceding years and lower in later years, reflecting more efficient production methods, resource utilization, and vehicle design derived from cumulative production experience. The average cost per vehicle for 1999 of $3.66 is the learning curve cost of $17.85 multiplied by 0.2053 (the percentage of passenger cars meeting FMVSS No. 201 in 1999).

Table 8 Example Calculation of Average Cost For Learning Curve					
Year	**Base 2001 Cost**	**Learning Factor**	**Cost per Vehicle**	**Percent of Veh. Comply**	**Average Cost per Vehicle**
1999	$14.80	1.206	$ 17.85	20.53	$ 3.66
2000	$14.80	1.068	$ 15.81	47.54	$ 7.52
2001	$14.80	1.000	$ 14.80	63.43	$ 9.39
2002	$14.80	0.947	$ 14.01	71.55	$ 10.03
2003	$14.80	0.904	$ 13.39	100	$ 13.39
2004	$14.80	0.876	$ 12.96	100	$ 12.96
2005	$14.80	0.855	$ 12.65	100	$ 12.65
2006	$14.80	0.838	$ 12.40	100	$ 12.40
2007	$14.80	0.825	$ 12.21	100	$ 12.21
2008	$14.80	0.815	$ 12.07	100	$ 12.07
2009	$14.80	0.809	$ 11.97	100	$ 11.97
2010	$14.80	0.802	$ 11.87	100	$ 11.87
2011	$14.80	0.795	$ 11.77	100	$ 11.77
2012	$14.80	0.788	$ 11.66	100	$ 11.66

Figure 1 presents an example of how the learning curve eventually reaches a point where costs decline at such a slow rate that the impact of further production is relatively insignificant. It illustrates the practical impact of cumulative learning over time using a hypothetical production schedule for a new technology. The increments indicated on the x axis represent successive years in a technologies' production life. In this example, successive doublings of cumulative production occur in the first few years as production is ramped up over the initial levels that occurred as the technology was introduced into the fleet, possibly in luxury or specialty vehicles. However, within a few years cumulative volume exceeds the stabilized annual production volume, and doubling becomes increasingly difficult to obtain. Figure 1 reflects the natural limitation on increases in cumulative volume (and thus learning) that result from the finite nature of annual production levels.

FIGURE 1



What has changed compared to the 2004 report? -

In 2004, NHTSA published its first report on the cost and weight of NHTSA's safety standards.[11] That report provided estimates from MY 1968 to MY 2001 vehicles. If we examine the last year in the 2004 report (MY 2001) and compare it to the results in this report for MY 2001, the results are fairly different for a variety of reasons. Table 9 updates the 2004 report economics to 2012 economics and provides information from the two reports for MY 2001 vehicles.

[11] Tarbet, M. J. (2004, December). *Cost and weight added by the Federal Motor Vehicle Safety Standards for model years 1968-2001 in passenger cars and light trucks* (Report No. DOT HS 809 834). Washington, DC: National Highway Traffic Safety Administration. Available at www.nhtsa.gov/cars/rules/regrev/evaluate/pdf/809834Part1.pdf and www.nhtsa.gov/cars/rules/regrev/evaluate/pdf/809834Part2.pdf

Table 9				
Comparison of 2004 Cost Report to This Cost Report For MY 2001 Vehicles				
	Passenger Cars		**LTVs**	
	Added Weight	**Cost 2012 $**	**Added Weight**	**Cost 2012 $**
2004 Report				
Attributable	125.4	$1,035.93	86.2	$877.58
This Report				
Attributable	104.7	$816.97	60.1	$637.70
Voluntary	32.6	$494.66	35.3	$606.47
Total	137.3	$1,311.63	95.4	$1,244.17

There are several differences in the definitions of attributable and voluntary between the reports, the technologies covered by the reports, and in the methodologies used, that result in different estimates. This report makes a distinction between voluntary and attributable costs based on the date of the NPRM. The 2004 report did not estimate the voluntary weight and costs that were installed on vehicles in MY 2001. Many safety countermeasures or baseline installation percentages that were assumed to be voluntary in this report were considered attributable to the standard in the 2004 report. Some safety technologies that were included as attributable in the 2004 report, were not included in this report because they were installed in all vehicles before an NPRM was published in the Federal Register. Other safety technologies that were not included in the 2004 report, like power brakes, were included in this analysis. One of the most important reasons for the differences in cost is that the 2004 report did not include ABS. The current report has higher costs because it includes ABS, whereas the 2004 report did not; this is because ABS has now become linked to the FMVSS by the ESC NPRM, but that NPRM had not yet been issued when we were writing the 2004 report.

This report applies a different methodology, a learning curve to cost, while the 2004 report did not. The learning curve reduced the cost for most of the standards in later years after their introduction. However, as shown in Table A-3 of the sensitivity analysis, in MY 2000 the learning curve had little impact on overall cost, and we would expect little impact in MY 2001. More importantly, new teardown data on some FMVSS became available. For example, a new teardown on frontal air bags resulted in an estimate that MY 2001 frontal air bags were 8.7 pounds lighter but almost the exact same price as the previous study. Data on some other standards (e.g., FMVSS No. 201 upper interior padding, and FMVSS No. 225 LATCH) were not available at the writing of the 2004 report and added weight and cost to this report. These various differences make it difficult to compare the two studies without examining each standard in detail.

Methods Used to Find Federal Register Notices -

In order to find past NPRMs and final rules in the Federal Register, several methods were used. First, many of the citations were included in the reference section under FR in the Kahane report *Lives Saved by Vehicle Safety Technologies and Associated Federal Motor Vehicle Safety Standards, 1960 to 2012,* January 2015, DOT HS 812 069. Second, in the NHTSA web page www.nhtsa.gov under DATA, regulatory analysis regulatory analyses from January 1971 to December 2013 many of the analyses from 1991 and later have the Federal Register cite and date and docket number. One can then go to the docket under www.regulations.gov and search using the docket number (e.g. nhtsa-2011-0148) to find the final rule. Or one can go to www.archives.gov under search our publications then daily federal register, search on-line which takes you to www.gpo.gov to find the Federal Register on line from 1994 onwards. Third, to find Federal Register articles before these dates, we went to a subscription service www.shop.heinonline.org. To use this service it helps to have a Federal Register cite. For most standards this can be found at the end of the standard in the Code of Federal Regulations (CFR). The CFRs from 1994 to present can be found on-line at www.gpo.gov look for Title 49 for Transportation. Usually the citations remain with the CFR, so you don't have to search older ones. This is one way to find how petitions for reconsideration amended the original standards. Once we found the Federal Register cites we went to Heinonline, entered the cites and pulled up the actual Federal Register notice and read through it to find the information we were interested in. Every final rule in the Federal Register always refers back to the NPRM and provides the Federal Register cite for it. Heinonline can also be searched for key words and dates, such as power windows in the years from 1966 to 1970, and it will refer you to each of the entries in which power windows appears during that time frame. Heinonline has both Federal Register and copies of the CFR. The end of this report contains a list of the Federal Register cites reviewed while working on this analysis.

SECTION 2 - FMVSS 100 SERIES

The FMVSS 100 series specify design and/or performance requirements for vehicles and vehicle subsystems that pertain to crash avoidance. The design-based standards require the presence of certain vehicle subsystems, specify design characteristics (size, shape, color, etc.)., and describe how particular subsystems are to function. Thereby, they provide a large degree of uniformity in the operation of all make-models of vehicles. The performance-based standards outline specific capabilities that a vehicle or vehicle subsystem must demonstrate when actively tested. Several of the FMVSS 100 series contain a set of both design-based and performance-based criteria.

FMVSS No. 101, Controls and displays

FMVSS No. 101 took effect on January 1 , 1968, and specifies requirements for the location, identification, and illumination of motor vehicle hand-operated controls (steering wheel, horn, ignition, etc.), foot-operated controls (service brake, accelerator, clutch, etc.), and displays (speedometer, turn signal, gear position indicator, etc.). The purpose of this standard is to ensure the accessibility and visibility of motor vehicle controls and displays and to facilitate their selection under daylight and nighttime conditions. The intent of the standard is to reduce the safety hazards caused by the diversion of the driver's attention from the driving task and by mistakes in selecting controls. Furthermore, drivers can more easily operate an unfamiliar vehicle if the controls and displays are in somewhat uniform locations with uniform labels. FMVSS No. 101 does not require uniform locations for all controls and displays, but does require uniform symbols and labels for most controls and displays. This standard applies to passenger cars, multipurpose passenger vehicles, trucks, and buses. Thus, it applies to all LTVs.

Most motor vehicles had some form of controls and displays prior to the standard. The requirements resulted in simply relocating and changing the visual appearance of the display. While there may have been a one-time development cost in some cases, there is little long-term cost associated with complying with the standard. No cost studies have been performed, and none are planned by NHTSA.

FMVSS No. 102, Transmission shift lever sequence, starter interlock, and transmission braking effect

FMVSS No. 102 took effect on January 1, 1968, and specifies the requirements for the transmission shift lever sequence, a starter interlock, and a braking effect of automatic transmissions. The purpose of this standard is to prevent shifting errors in unfamiliar vehicles, or when drivers change from one vehicle to another. It requires a starter interlock to prevent drivers from engaging the starter with the vehicle in a driving gear. It also requires automatic transmissions to have a low gear selection to provide a supplemental braking effect at speeds below 25 miles per hour. For vehicles equipped with manual transmissions, the standard requires a display of the shift pattern that is in the driver's field of view. This standard applies to passenger cars, multipurpose passenger vehicles, trucks, and buses. Thus, it applies to all LTVs.

The standard requires that all shift levers for automatic transmissions have the same clockwise sequence: park, reverse, neutral, drive, and low gear(s). This will reduce the likelihood of shifting errors when drivers change from one vehicle to another. Effective September 23, 1991, the identification of shift lever positions shall be displayed in view of the driver in a single location. Identification of the shift lever pattern for manual transmissions shall be displayed in view of the driver at all times when a driver is present in the driver's seating position. Vehicles with a 3-speed manual transmission that has the standard H pattern shift sequence are not required to have a shift pattern display.

While there may have been a one-time development cost in some cases, there is little long-term cost associated with complying with the standard. No cost studies have been performed, and none are planned by NHTSA.

FMVSS No. 103, Windshield defrosting and defogging systems

FMVSS No. 103 took effect on January 1, 1968, and specifies requirements for windshield defrosting and defogging systems. The purpose of this standard is to establish minimum capability for all vehicles to assure that windshields will remain clear under conditions in which moisture could adhere to the inside or outside of the windshield. It is based on passenger cars meeting the requirements of the Society of Automotive Engineers (SAE) recommended practices established in 1964. The other vehicle classes under this standard are required to have windshield defrosting and defogging systems; however, no performance requirements are specified. The defrosting and defogging system includes the necessary ducts, baffles, cables, levers, and grilles to direct heated or dehumidified air onto the windshield. This standard applies to passenger cars, multipurpose passenger vehicles, trucks, and buses. Thus, it applies to all LTVs.

A study of seven pre-standard make-model passenger cars, and their corresponding post-standard systems, revealed minimal design changes resulting in a reduction of average weight and a slight increase of average consumer cost. However, NHTSA has no evidence that these changes were specifically made to meet performance requirements in the standard.[12] Table 103-1 shows the sales-weighted average for the weight and consumer cost of windshield defrosting and defogging systems in pre- and post-standard passenger cars.

TABLE 103-1
AVERAGE WEIGHT AND CONSUMER COST
OF WINDSHIELD DEFROSTING AND DEFOGGING SYSTEMS
IN PASSENGER CARS

MODEL YEAR	WEIGHT IN POUNDS	CONSUMER COST ($2012)
1965 (Pre-Standard)	1.23	$11.12
1969 (Post-Standard)	1.01	$12.04

[12] Gilmour, J. L. (1982, June). *Consumer cost evaluation of Federal Motor Vehicle Safety Standards – FMVSS 103 and 104* (Report No. DOT HS 806 205) Washington, DC: National Highway Traffic Safety Administration, Docket No. 2011-0066-0067.

A study of seven 1969 make-model LTVs indicated that the sales-weighted average weight and consumer cost of the defrosting and defogging systems was 3.05 pounds and $12.36 in 2012 dollars.[13] Although not studied, earlier model LTVs were also equipped with these systems.

The final rule for passenger cars and LTVs was published in the Federal Register on April 27, 1968, (33 FR 6465), and the NPRM on December 28, 1967, (32 FR 20865) making the baseline date September 1, 1967, or MY 1968. Since 100 percent of the fleet had windshield defrosting and defogging systems by the baseline date, and there are no indications that the minimal design changes between 1965 and 1969 were made to meet the performance tests of the standard, there are no incremental costs. The cost of the equipment that was already there will not be considered as voluntarily provided before the NPRM and will not be attributed to the FMVSS.

FMVSS No. 103 has never required or proposed to require rear-window defrosters and defoggers. Their development has been voluntary on the part of the industry, in response to customer demand. Drivers want a clear rear window, and they like a device that clears it for them automatically, so they do not have to wipe or scrape it repeatedly. NHTSA has evaluated rear-window defrosters and defoggers and was unable to conclude that they reduce police reported crashes.[14] NHTSA has no cost and weight teardown studies of rear-window defrosters and defoggers and has no plans to study them. Thus, while rear-window defrosters and defoggers are standard equipment on most light vehicles, they are not included in this analysis.

FMVSS No. 104, Windshield wiping and washing systems

FMVSS No. 104 took effect on January 1, 1968, for passenger cars and January 1, 1969, for LTVs and specifies requirements for windshield wiping and washing systems. The standard requires that each vehicle have a power-driven windshield wiping system with two speeds, with the speed of the wiping system independent of the vehicle engine speed and engine load. It essentially mandated electric-powered wiper motors and precluded the early design of wiper systems that were driven by the vehicle's engine vacuum. In addition, each vehicle shall have a windshield washing system that meets the requirements based on SAE recommended practices established in 1965. This standard applies to passenger cars, multipurpose passenger vehicles, trucks, and buses. Thus, it applies to all LTVs.

Intermittent windshield wipers were never required or proposed by NHTSA. NHTSA has never attempted to evaluate whether these systems improve safety, nor estimated their costs with a teardown study, and there are no plans to study them. Thus, while intermittent windshield wipers are standard equipment on most light vehicles, they are not included in this analysis.

The final rule for passenger cars was published in the Federal Register on February 3, 1967, (32 FR 2410) and the NPRM on December 3, 1966, (31 FR 15212) making the baseline date for

[13] Gladstone, R., Harvey, M. R., & Lesczhik, J. A. (1982, November). *Estimation of weight and consumer price relating to the implementation of FMVSS 201 in passenger cars and FMVSS 103 and 104 in LTVs* (Report No. DOT HS 806 367). Washington, DC: National Highway Traffic Safety Administration, Docket No. 2011-0066-0063.

[14] Morgan, C. (2004, March). *Evaluation of rear window defrosting and defogging systems*. (Report No. DOT HS 809 724). Washington, DC: National Highway Traffic Safety Administration. Available at www-nrd.nhtsa.dot.gov/Pubs/809724.pdf

passenger cars September 1, 1966, or MY 1967. On April 27, 1968, (33 FR 6465), the standard was extended to LTVs with the NPRM on December 28, 1967, (32 FR 20865) making the baseline date for LTVs September 1, 1967, or MY 1968.

Passenger Car Studies

When FMVSS No. 104 was issued, all passenger cars were equipped with both windshield wiping and washing systems. After studying seven pre-standard 1965 make-model passenger cars, the contractor concluded that the vehicles already complied with the standard.[15] Since every passenger car that came under the standard was equipped with a windshield wiping and washing system before the baseline date of MY 1967, and there are no indications that the countermeasures were upgraded as a result of the standard, there are no incremental costs. The cost of the equipment that was already there will not be considered as voluntarily provided before the NPRM and will not be attributed to the FMVSS.

LTV Studies

The windshield wiping and washing systems for seven MY 1969 make-model LTVs were also studied.[16] They were compared to MY 1965 LTVs which were equipped with one-speed wiper motors and did not have washing systems at all. The cost of implementing the windshield wiper requirements was determined by comparing the single and multi-speed motors, an additional wire from the switch to the motor, and a switch that was changed from two positions to three positions. In the case of the variable speed motors, a variable switch was substituted for the two-position switch. Table 104-1 shows the sales-weighted average weight and consumer cost of each system, with the difference being the cost of implementing the windshield wiper requirements.

TABLE 104-1
AVERAGE WEIGHT AND CONSUMER COST
OF WINDSHIELD WIPER SYSTEMS IN LTVS

MOTOR TYPE	WEIGHT IN POUNDS	CONSUMER COST ($2012)
Single Speed	2.23	$23.96
Multi-Speed	2.72	$28.92
DIFFERENCE	0.49	$ 4.96

For the washing systems analysis, the MY 1965 LTVs were without the system and needed the following components (reservoir, pump, hoses, switch and knob assembly). The sales-weighted average weight and consumer cost for these additional systems was 1.61 pounds and $13.62 in 2012 dollars.

Table 104-2 shows the total weight and consumer cost for FMVSS No. 104 comparing MY 1969 to MY 1965 LTVs.

[15] Gilmour, DOT HS 806 205:82-144 (1982), Docket No. 2011-0066-0067.
[16] Gladstone, Harvey, & Lesczhik, DOT HS 806 3671982), Docket No. 2011-0066-0063.

TABLE 104-2 AVERAGE WEIGHT AND CONSUMER COST OF WINDSHIELD WIPING AND WASHING SYSTEMS IN LTVS		
SYSTEM	**WEIGHT IN POUNDS**	**CONSUMER COST ($2012)**
Windshield Wiping	0.49	$ 4.96
Windshield Washing	1.61	$13.62
TOTAL	2.10	$18.59

Windshield wiping and washing systems that met FMVSS No. 104 were available in 100 percent of passenger cars by MY 1965 and 100 percent of LTVs in MY 1968.

Table 104-3 shows the results after applying the learning curve to consumer costs for LTVs in case the reader wants to apply a different baseline assumption. Weight stays the same, since we do not have a learning curve for weight, but consumer costs decrease as manufacturers find ways to reduce costs over time. We use a progress rate in the learning curve of 0.93. In this case, we know that the cost of wipers and washers has undoubtedly increased due to refinements such as intermittent wipers, switches that activate the headlamps when you turn on the wipers, and washers with even bigger reservoirs, etc. These subsequent improvements, even though they make passenger cars and LTVs safer, are not required by any FMVSS so we aren't counting any cost for them. In addition, we don't have cost estimates for these improvements in the wiping and washing systems.

Table 104-3					
Windshield Wiping and Washing System					
Weight (lb) and Cost (2012$)					
For LTVs					
Model Year	**Weight**	**Consumer Cost**	**Model Year**	**Weight**	**Consumer Cost**
1968	2.1	$18.86	1991	2.1	$15.95
1969	2.1	$18.58	1992	2.1	$15.90
1970	2.1	$18.37	1993	2.1	$15.84
1971	2.1	$18.15	1994	2.1	$15.78
1972	2.1	$17.95	1995	2.1	$15.72
1973	2.1	$17.74	1996	2.1	$15.67
1974	2.1	$17.60	1997	2.1	$15.61
1975	2.1	$17.47	1998	2.1	$15.56
1976	2.1	$17.32	1999	2.1	$15.50
1977	2.1	$17.18	2000	2.1	$15.45
1978	2.1	$17.04	2001	2.1	$15.39
1979	2.1	$16.92	2002	2.1	$15.34
1980	2.1	$16.83	2003	2.1	$15.30
1981	2.1	$16.75	2004	2.1	$15.25
1982	2.1	$16.67	2005	2.1	$15.20
1983	2.1	$16.59	2006	2.1	$15.16
1984	2.1	$16.50	2007	2.1	$15.12
1985	2.1	$16.40	2008	2.1	$15.09
1986	2.1	$16.31	2009	2.1	$15.06
1987	2.1	$16.22	2010	2.1	$15.03
1988	2.1	$16.14	2011	2.1	$15.00
1989	2.1	$16.07	2012	2.1	$14.97
1990	2.1	$16.01			

Since 100 percent of the fleet had windshield wiping and washing systems by the baseline date, MY 1967 for passenger cars and MY 1968 for LTVs, and there are no indications that changes were made to meet the performance tests of the standard, there are no incremental costs. The cost of the equipment that was already there will not be considered as voluntarily provided before the NPRM and will not be attributed to the FMVSS.

FMVSS No. 105, Hydraulic and electric brake systems

FMVSS No. 105 took effect on January 1, 1968, and specifies requirements for vehicles equipped with hydraulic and electric service brake systems, and associated parking brake systems. The purpose of this standard is to ensure safe braking performance under normal and emergency conditions. This standard applies to:

- hydraulically braked passenger cars manufactured before September 1, 2000;
- hydraulically braked multipurpose passenger vehicles, trucks, and buses (including all LTVs) with a GVWR of 7,716 pounds or less that were manufactured before September 1, 2002; and
- hydraulically braked vehicles with a GVWR greater than 7,716 pounds.

All hydraulically braked passenger cars manufactured after September 1, 2000, and hydraulically braked multipurpose passenger vehicles, trucks, and buses (including all LTVs) with a GVWR of 7,716 pounds or less that were manufactured after September 1, 2002, are part of FMVSS No. 135 (Light Vehicle Brake Systems). In the following tables, FMVSS No. 105 and FMVSS No. 135 are combined since safety countermeasures (like dual master cylinders, power boosters, disc brakes and ABS) used to meet the standards are discussed and there were no other new costs added to passenger cars and LTVs as a direct result of FMVSS No. 135.

Passenger Car Studies
Brake System Components

The brake system components specifically required by FMVSS No. 105 are a dual or split hydraulic service brake system, parking brake system, and brake system indicator lamp. Particular design characteristics of these components are also governed by this standard. The performance requirements for brake systems consist of a series of stopping tests simulating normal and emergency braking, fade and recovery, water recovery, and partial system failure.

The most important indication of brake performance is the distance in which a brake system can stop a vehicle from a given speed. The performance requirements for the service brake system are expressed in terms of stopping distance and/or deceleration rates from specific vehicle speeds using a specific range of brake pedal apply forces by the vehicle driver. Brake pedal apply force is measured in pounds per foot and is an indication of how hard the vehicle driver's leg pushes against the brake pedal.

Fade and recovery requirements are also included in the standard to assure that a vehicle's braking performance is satisfactory when exposed to the high brake temperatures caused by prolonged or severe use or during the time that the brakes are cooling off after severe use. Fade is the inability of friction material to maintain its normal effectiveness when it is forced to work at elevated temperatures. Recovery is the rate at which the lining returns to its original friction level after having been exposed to a fade condition. Light fade occurs in vehicles even in low speed applications such as in heavy traffic. Moderate to severe fade is a condition that may occur when vehicles are used on hilly or mountainous roads, especially when heavy loads are carried. In addition, water recovery requirements are included in the standard to assure that a vehicle's braking system performs adequately after immersion in water. Finally, partial system failure requirements are included to ensure that a vehicle's brakes are capable of bringing the vehicle to a controlled stop in a reasonable distance if a part of the service brake system should fail.

Each vehicle shall be capable of completing all performance requirements without:

- detachment or fracture of any component of the braking system, and
- any visible brake fluid or lubricant on the friction surface of the brake or leakage at the master cylinder or brake power unit reservoir cover, seal, and filler openings.

FMVSS No. 105, effective in January 1968, represented the initial Federal effort to specify braking requirements for motor vehicles and required that passenger cars be equipped with a split service brake system and have stopping ability based upon deceleration rates specified in the SAE Recommended Practice J937, June 1966. Requirements for fade and recovery, water recovery, and stability while braking were also included in this standard. These requirements did not represent the full capabilities of modern braking technology; therefore, a new standard (105a) was established in September 1972 specifying requirements for motor vehicle hydraulic brake systems and parking brake systems.

FMVSS No. 105 is a performance standard, specifying stopping distances or deceleration rates for a series of stopping tests under various conditions. It does not prescribe technologies. However, dual master cylinders satisfied the FMVSS No. 105 requirement for a dual or split braking system. The goal of dual master cylinders is to provide dual hydraulic circuits, so that a fault in one hydraulic system will not lead to a catastrophic loss of all braking power.

The NPRM for the initial FMVSS, including FMVSS No. 105 was published in the Federal Register on December 3, 1966, (31 FR 15212) making the baseline date September 1, 1966, or MY 1967. The baseline date is the model year that occurs prior to the NPRM being published in the Federal Register. Since dual master cylinders were installed in all passenger cars in MY 1967, they are considered part of the baseline and no costs are attributable or voluntary for dual master cylinders.

The principal difference between the 1968 and 1976 standards is that the new regulation specifies the straight-line stopping distances within which a car must stop under good conditions. The older rule merely specified the deceleration rate a car had to attain at some point during braking. Moreover, the stopping distances were set at a level that only half of the 1972 models appeared to be capable of meeting, according to consumer information data submitted to NHTSA by the manufacturers. In other words, it was felt that the new regulation would significantly improve stopping distances over 1972 levels in a large portion of the vehicle fleet. The new regulation requires more stringent partial failure, fade recovery, and water recovery tests than the older rule. In addition, the following requirements for improved handling and stability are added:

- wheel lockup is permitted at a speed below 10 miles per hour, and
- lockup of only one wheel, not controlled by an antilock system, is permissible at speeds in excess of 10 miles per hour.

It is difficult to determine what costs should be attributed to FMVSS No. 105 because changes in vehicle size, customer preferences, and development of superior materials and designs have all enhanced or changed braking performance, cost, and weight over the years. The four major changes to the braking systems that have occurred since 1965 are dual master cylinders, front disc brakes, brake power assist units (power boosters), and antilock brake systems (ABS). Each of these will be discussed separately. Table 105-1 shows the estimated percentage of passenger cars with these technologies by model year. The percentage of the passenger car fleet with power boosters for MY 1969, MY 1970, and MY 1971 could not be found in the literature and was assumed to linearly increase between the years with known data of MY 1968 and MY 1972. In addition, in the years before 1985 most of the known data are for domestic vehicles. In the years that data were not available for import passenger cars, we assumed the same percentage of braking countermeasures were installed in import passenger cars as could be found in the literature for domestic passenger cars.

Manufacturers had extensive advance knowledge of the upgrade to establish FMVSS No. 105a for passenger cars because a Notice of Proposed Rulemaking (NPRM) was issued November 11, 1970, (35 FR 17345) making the baseline date September 1, 1970, or MY 1971. FMVSS No, 105a was redesignated to FMVSS No. 105-75 in February 1974, and with only minor changes in the portion applicable to passenger cars, evolved into the January 1976 requirements. Power boosters were used to help meet the stopping distance requirements. Power boosters were not available in all passenger cars by the baseline date of MY 1971. Front disc brakes helped vehicles pass the fade and water-recovery tests.

Table 105–1

Percentage of Passenger Cars with Dual Master Cylinders, Front Disc Brakes, Power Boosters, and ABS by Model Year

Model Year	Dual Master Cylinder	Front Disc Brakes	Power Boosters	Four-Wheel ABS	Rear-Wheel ABS
1960	0	0	26	0	0
1961	0	0	26	0	0
1962	9	0	26	0	0
1963	9	0	26	0	0
1964	7	0	29	0	0
1965	7	2	32	0	0
1966	54	3	35	0	0
1967	100	6	38	0	0
1968	100	13	41	0	0
1969	100	28	44	0	0
1970	100	41	47	0	0
1971	100	63	50	0	0
1972	100	74	68	0	0

1973	100	86	67	0	0
1974	100	84	67	0	0
1975	100	93	74	0	0
1976	100	99	81	0	0
1977	100	100	85	0	0
1978	100	100	88	0	0
1979	100	100	88	0	0
1980	100	100	89	0	0
1981	100	100	89	0	0
1982	100	100	90	0	0
1983	100	100	93	0	0
1984	100	100	96	0	0
1985	100	100	97	0	0
1986	100	100	99	1.7	0
1987	100	100	99	4.5	0.180
1988	100	100	100	5.1	0.082
1989	100	100	100	6.4	0.047
1990	100	100	100	11.1	0
1991	100	100	100	17	0
1992	100	100	100	32.2	0
1993	100	100	100	41.2	0
1994	100	100	100	55.5	0
1995	100	100	100	55.9	0
1996	100	100	100	58	0
1997	100	100	100	57.3	0
1998	100	100	100	60.7	0
1999	100	100	100	65.4	0
2000	100	100	100	63.1	0
2001	100	100	100	61.8	0
2002	100	100	100	62.5	0
2003	100	100	100	57.7	0
2004	100	100	100	61.3	0
2005	100	100	100	62.7	0
2006	100	100	100	71.5	0
2007	100	100	100	76.9	0
2008	100	100	100	79.9	0
2009	100	100	100	85.5	0
2010	100	100	100	97.4	0
2011	100	100	100	98.8	0
2012	100	100	100	100	0

Dual Master Cylinders. Dual master cylinders were explicitly required by FMVSS No. 105 beginning on January 1, 1968, and were already implemented in all 1967 passenger cars. Dual master cylinders are the chief component of a split or dual brake system. A typical passenger car or LTV has a friction brake at each of its four wheels. These brakes are actuated through hydraulic pressure provided by the master cylinder as the brake pedal is depressed. A single brake system provides hydraulic fluid from one reservoir source to all four wheels. A typical split or dual brake system has two separate hydraulic circuits with a reservoir for the front brakes and one for the rear brakes. There are other dual braking systems that use a diagonal arrangement that has two circuits, each with one front wheel and one rear wheel on the opposite side of the vehicle. Without dual master cylinders, a failure in the brake hydraulic system can lead to a complete loss of braking capability. With dual brakes, however, if one of the circuits fails, the vehicle will retain braking capability with the other circuit. FMVSS No. 105 requires that vehicles must be able to stop within a specified distance from 60 miles per hour when one of the brake hydraulic circuits is disabled. Furthermore, a brake warning light is required to illuminate whenever there is a gross loss of hydraulic pressure in one of the circuits.

Even though this analysis assumes dual master cylinders are part of the baseline and not attributable to the FMVSS, NHTSA has done a teardown analysis of dual master cylinders and the weight and cost estimates are provided here for informational purposes.

Forty-one make-model passenger cars representing pre-standard, post-standard, and trend systems were studied,[17] along with thirteen downsized make-model passenger cars.[18] Table 105-2 shows the sales-weighted average for the weight and consumer cost of master cylinders in 2012 dollars.

TABLE 105-2
AVERAGE WEIGHT AND CONSUMER COST
OF MASTER CYLINDERS IN PASSENGER CARS

CATEGORY	WEIGHT IN POUNDS	CONSUMER COST ($2012)
Single (Pre-Standard)	4.38	$32.75
Dual (Post-Standard)	6.12	$47.74
Dual (Trend)	7.97	$44.38
Dual (Downsized)	3.33	$42.79

Table 105-2 suggests that master cylinders decreased significantly in weight in the downsized passenger cars. The decrease was the result of a new, smaller cast-iron design and a new two-piece master cylinder unit with an aluminum-alloy bore and either a stamped steel or plastic reservoir.

[17] Harvey, M. R., Lesczhik, J. A., & McLean, R. F. (1979, November). *Cost evaluation for nine Federal Motor Vehicle Standards, Volume 1, FMVSS 105* (Report No. DOT HS 805 315). Washington, DC: National Highway Traffic Safety Administration, Docket No. 2011-0066-0012.

[18] Gladstone, R., Harvey, M. R., Lesczhik, J., & McLean, R. (1982, August). *Estimation of Weight and Consumer Price Relating to the Implementation of FMVSS 105, 108, 202, 205, & 216, in Passenger Cars and 201, 203, & 204 in LTVs* (Report No. DOT HS 806 769). Washington, DC: National Highway Traffic Safety Administration. (DOT HS 806 769:2-1 thru 2-19), Docket No. 2011-0066-0013.

To accurately allocate the average weight and consumer cost attributable to the standard in any given model year, it is necessary to separate the master cylinders into three time periods. Two conditions exist for the calculations. First, we assume that the average weight and consumer cost decreased at a linear rate from 1976 to 1982 and leveled off after that. Second, it is necessary to calculate what the weight and cost of master cylinders would have been if they had remained single instead of dual (because, presumably, the weight-saving technologies described above could also have been applied to a single master cylinder). The weight and cost figures are calculated using the following formulas.

1. Average Cost of Master Cylinders (1966-1976) =

   Cost of Post-Standard Dual Master Cylinders – Cost of Pre-Standard Single Master Cylinders = $47.74 - $32.75 = $14.99

2. Average Cost of Master Cylinders (if they had remained single) =

   (Cost of Downsized Dual Master Cylinders/Cost of Post-Standard Dual Master Cylinders) * Cost of Pre-Standard Single Master Cylinders = ($42.79/$47.74) * $32.75 = $29.36

3. Average Cost of Master Cylinders (1982-2002) =

   Cost of Downsized Dual Master Cylinders – Cost of Master Cylinders (if they had remained single) = $42.79 – 29.36 = $13.43

4. Average Cost of Master Cylinders (CY), where 1977 ≤ CY ≤ 1981, =

   Costs in this time period are distributed by 83.33/16.67%, 66.67/33.33%, 50/50%, 33.33/66.67%, and 16.67/83.33% for the 5 model years respectively with the first percentage * $14.99 + the second percentage * $13.43. Thus, 1977, is 0.8333*$14.99 + 0.1667*13.43.

   The learning curve is applied starting in 1982 assuming that the average cost of $13.43 applies to MY 1982 models.

5. Average Weight of Master Cylinders (1966-1976) =

   Weight of Post-Standard Dual Master Cylinders – Weight of Pre-Standard Single Master Cylinders = 6.12 – 4.38 = 1.74

6. Average Weight of Master Cylinders (if they had remained single) =

   (Weight of Downsized Dual Master Cylinders/Weight of Post-Standard Dual Master Cylinders) * Weight of Pre-Standard Single Master Cylinders = (3.33/6.12) * 4.38 = 2.38

7. Average Weight of Master Cylinders (1982-2002) =

Weight of Downsized Dual Master Cylinders – Weight of Master Cylinders (if they had remained single) = 3.33 – 2.38 = 0.95

8. Average Weight of Master Cylinders (CY), where 1977 ≤ CY ≤ 1981, =

Weights are distributed by 83.33/16.67, 66.67/33.33, 50/50, 33.33/66.67, and 16.67/83.33% for the 5 model years respectively with the first percentage * 1.74 + the second percentage * 0.95. Thus, 1977, is 0.8333*$1.74 + 0.1667*0.95.

Table 105-3 shows the average incremental weight and consumer cost of dual master cylinders in passenger cars by model year after applying the learning curve. That is, incremental weight and cost over the standard single master cylinder. Again, this is for informational purposes only. Because dual master cylinders were installed in 100 percent of passenger cars in the baseline year for this standard (MY 1967) these costs are not included in the attributable or voluntary costs summary tables.

TABLE 105-3 AVERAGE INCREMENTAL WEIGHT AND CONSUMER COST OF DUAL MASTER CYLINDERS IN PASSENGER CARS BY MODEL YEAR		
MODEL YEAR	**WEIGHT IN POUNDS**	**CONSUMER COST ($2012)**
1966-1976	1.74	$14.99
1977	1.61	$14.73
1978	1.48	$14.47
1979	1.35	$14.21
1980	1.21	$13.95
1981	1.08	$13.69
1982	0.95	$13.43
1983	0.95	$13.37
1984	0.95	$13.31
1985	0.95	$13.24
1986	0.95	$13.18
1987	0.95	$13.13
1988	0.95	$13.07
1989	0.95	$13.03
1990	0.95	$12.98
1991	0.95	$12.95
1992	0.95	$12.91
1993	0.95	$12.87
1994	0.95	$12.83
1995	0.95	$12.80
1996	0.95	$12.76
1997	0.95	$12.73
1998	0.95	$12.69
1999	0.95	$12.66
2000	0.95	$12.62
2001	0.95	$12.59
2002	0.95	$12.56
2003	0.95	$12.53
2004	0.95	$12.50
2005	0.95	$12.47
2006	0.95	$12.44
2007	0.95	$12.42
2008	0.95	$12.40
2009	0.95	$12.38
2010	0.95	$12.36
2011	0.95	$12.34
2012	0.95	$12.32

Front Disc Brakes. A change in the brake systems that was encouraged, although not required because of FMVSS No. 105, was the conversion of front brakes from a drum to a disc design. Disc brakes require less time to recover braking ability after being partially or fully submerged in water, plus they dissipate heat faster and are less likely to fade after repeated applications (e.g., on a long downhill grade). Furthermore, consumers prefer the superior feel of the car's braking power. Disc brakes experience linear relationships between brake pedal apply force and vehicle deceleration, without the tendency to grab like drum brakes. Manufacturers were encouraged by the capability of front disc brakes to meet the fade and recovery and water recovery requirements contained in FMVSS No. 105.

Front disc brakes began to appear on domestic passenger cars in MY 1965. Consumers welcomed the new technology. It jumped from 13 percent of new cars in 1968 to 86 percent by 1973. The NPRM proposing FMVSS No. 105a was issued November 11, 1970, (35 FR 17345) making the baseline date September 1, 1970, or MY 1971. Although some cars with four-wheel drum brakes could and did pass the new tests, it was easier to meet them with front disc brakes. Furthermore, the superior self-adjusting characteristics of disc brakes allowed for increased vehicle stability during the high-speed stopping tests in FMVSS No. 105. By MY 1978, most cars and LTVs produced for sale in the United States were equipped with front disc brakes. (FMVSS No. 105 or 135 have never explicitly required disc brakes).

The test for fade and recovery involved a repeated series of brake stops from a specific speed where the vehicle had to slow at a specific rate each time falling within minimum and maximum limits for brake pedal apply force. The test for water recovery ability involved driving a vehicle in any combination of forward and reverse directions through a trough having a water depth of six inches and then immediately performing a series of stops from 30 mph at a specified deceleration rate.

The sales-weighted average for the weight and consumer cost of front drum brakes from a sample of 1966 and 1968 model year vehicles was 57.47 pounds and $200.00 in 2012 dollars. The front drum brake system included the brake drum, brake shoes with lining material, hydraulic wheel cylinder, brake adjuster, backing plate, springs, and miscellaneous hardware pieces. Early front disc brake systems (MY 1968 and 1976 passenger cars) weighed 70.99 pounds and cost $181.77 in 2012 dollars. In other words, the early disc brake systems weighed more but cost less than drum brakes. The front disc brake system included the brake disc rotor, caliper, mounting bracket and bolts, backing plate, and brake pads with friction lining material. By 1977-1982, various cost- and weight-reducing technological improvements had significantly lowered the cost of disc brakes. Downsizing of the entire vehicle, resulting in opportunities to use less massive braking systems, also contributed to the cost and weight reduction for brakes. The weight dropped to an average of 50.36 pounds, while the consumer cost dropped to an average of $93.08 in 2012 dollars. The role of FMVSS No. 105 in the shift to disc brakes is somewhat uncertain, but is a moot point since disc brakes, in the long term, had lower weight and cost than drum brakes.

Table 105-4 shows the overall weight and consumer cost of front brakes for the 1966/1968, 1968/1976, and 1977-1982 make-models years.

TABLE 105-4 AVERAGE WEIGHT AND CONSUMER COST OF FRONT BRAKES IN PASSENGER CARS		
CATEGORY	**WEIGHT IN POUNDS**	**CONSUMER COST ($2012)**
Overall		
Drum (1966/68)	57.47	$200.00
Disc (1968/76)	70.99	$181.77
Disc (1977-1982)	50.36	$ 93.08

Power Boosters. While power boosters are not explicitly required to meet FMVSS No. 105, power brakes do help vehicles to stop quickly, especially under high speed or hazardous conditions. The stopping distance requirements, in conjunction with the brake pedal apply force requirements of FMVSS No. 105, encouraged manufacturers to use power boosters. Although some cars without power boosters could and did pass the stopping distance tests, it was easier to meet them with power boosters. It was difficult to stop cars within the distance and at the pedal pressure specified in FMVSS No. 105 unless they had power brakes. Furthermore, consumers like power boosters because they amplify the force applied by the driver to the brake pedal and allow even small drivers and older drivers to achieve high levels of vehicle braking on all sizes of vehicles. We decided power boosters are linked to FMVSS No. 105 because NHTSA proposed and later required a performance standard on stopping distance that resulted in the power boosters being used.

Table 105-5 shows the sales-weighted average weight and consumer cost (before applying the learning curve) of power boosters for the 1966, 1968, 1976, and downsized 1977-1982 make-model passenger cars. For this analysis we assumed a linear increase in both cost and weight between 1968 and 1976, and then the learning curve was applied to costs starting in 1977. There was a significant reduction in weight and cost with downsizing in 1977.

TABLE 105-5 AVERAGE WEIGHT AND CONSUMER COST OF POWER BOOSTERS IN PASSENGER CARS				
MODEL YEAR	**WEIGHT IN POUNDS**	**CONSUMER COST ($2012) PER POWER BRAKE**	**% OF CARS WITH POWER BRAKES**	**CONSUMER COST ($2012) PER CAR**
1966	7.61	$55.90	35.31	$19.74
1968	9.27	$56.12	31.50	$17.68
1976	11.60	$67.63	80.90	$54.71
1977-1982	7.86	$49.59	84.24	$41.77

The NPRM proposing FMVSS No. 105a was issued November 11, 1970, (35 FR 17345) making the baseline date September 1, 1970, or MY 1971. Thus, the percentage of passenger cars equipped with power boosters in MY 1971 and earlier model years are considered voluntary, the installation rate of the MY 1971 baseline year (50% installation) is considered voluntary for all

MY 1972 and later passenger cars, and the difference between the percentage of the fleet with power boosters and 50 percent for all MY 1972 and later are considered attributable.

Table 105-6 shows the resulting voluntary and attributable estimated weights and costs for the average passenger car after applying the percentage of the passenger cars with power boosters found in Table 105-1. In this case there is no need to show a separate table with weights and costs after applying the learning curve and before the baseline, voluntary, and attributable decisions, because the total columns presents the same information.

Table 105-6

FMVSS No. 105 Power Boosters for Passenger Cars

Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	3.8	0	3.8	$23.01	0	$23.01
1969	4.2	0	4.2	$25.33	0	$25.33
1970	4.6	0	4.6	$27.73	0	$27.73
1971	5.1	0	5.1	$30.22	0	$30.22
1972	5.2	1.9	7.1	$30.94	$11.14	$42.08
1973	5.4	1.8	7.2	$31.66	$10.76	$42.42
1974	5.5	1.9	7.4	$32.38	$11.01	$43.38
1975	5.7	2.7	8.4	$33.10	$15.89	$48.98
1976	5.8	3.6	9.4	$33.82	$20.97	$54.78
1977	3.9	2.8	6.7	$24.80	$17.36	$42.15
1978	3.9	3.0	6.9	$24.46	$18.59	$43.06
1979	3.9	3.0	6.9	$24.20	$18.39	$42.59
1980	3.9	3.1	7.0	$24.00	$18.72	$42.71
1981	3.9	3.1	7.0	$23.82	$18.58	$42.41
1982	3.9	3.1	7.1	$23.67	$18.93	$42.60
1983	3.9	3.4	7.3	$23.49	$20.20	$43.69
1984	3.9	3.6	7.5	$23.29	$21.43	$44.72
1985	3.9	3.7	7.6	$23.09	$21.71	$44.80
1986	3.9	3.9	7.8	$22.90	$22.44	$45.34
1987	3.9	3.9	7.8	$22.73	$22.28	$45.01
1988	3.9	3.9	7.9	$22.57	$22.57	$45.15
1989	3.9	3.9	7.9	$22.44	$22.44	$44.87
1990	3.9	3.9	7.9	$22.31	$22.31	$44.62
1991	3.9	3.9	7.9	$22.21	$22.21	$44.41
1992	3.9	3.9	7.9	$22.10	$22.10	$44.20
1993	3.9	3.9	7.9	$21.99	$21.99	$43.99
1994	3.9	3.9	7.9	$21.88	$21.88	$43.77
1995	3.9	3.9	7.9	$21.78	$21.78	$43.56

1996	3.9	3.9	7.9	$21.68	$21.68	$43.36
1997	3.9	3.9	7.9	$21.59	$21.59	$43.17
1998	3.9	3.9	7.9	$21.49	$21.49	$42.99
1999	3.9	3.9	7.9	$21.40	$21.40	$42.79
2000	3.9	3.9	7.9	$21.30	$21.30	$42.60
2001	3.9	3.9	7.9	$21.21	$21.21	$42.42
2002	3.9	3.9	7.9	$21.13	$21.13	$42.25
2003	3.9	3.9	7.9	$21.05	$21.05	$42.09
2004	3.9	3.9	7.9	$20.97	$20.97	$41.94
2005	3.9	3.9	7.9	$20.89	$20.89	$41.79
2006	3.9	3.9	7.9	$20.82	$20.82	$41.64
2007	3.9	3.9	7.9	$20.76	$20.76	$41.51
2008	3.9	3.9	7.9	$20.70	$20.70	$41.41
2009	3.9	3.9	7.9	$20.66	$20.66	$41.32
2010	3.9	3.9	7.9	$20.62	$20.62	$41.23
2011	3.9	3.9	7.9	$20.57	$20.57	$41.14
2012	3.9	3.9	7.9	$20.52	$20.52	$41.03

Total Brake System. The total brake system (before ABS) includes the front and rear brake assembly, master cylinder, foot pedal and linkage, power booster, warning light, proportional valve, and parking brake system. For informational purposes Table 105-7 shows the sales-weighted average weight and consumer cost of the total brake system for the 1966, 1968, 1976, and 1977-1982 make-models. Again, the substantial drop in the weight and consumer cost of 1977-1982 brake systems is the result of specific new weight- and cost-saving brake technologies as well as the downsizing of the overall vehicle. Except for the cost impact of dual master cylinders in 1967 (which was considered to be in the baseline) and power boosters, there is little evidence that any of the other major cost changes over the years are directly related to FMVSS No. 105 or that these costs would have been different in the absence of the standard.

TABLE 105-7
AVERAGE WEIGHT AND CONSUMER COST
OF THE TOTAL BRAKE SYSTEM IN PASSENGER CARS

MODEL YEAR	WEIGHT IN POUNDS	CONSUMER COST ($2012)
1966	132.60	$585.98
1968	147.33	$623.05
1976	166.69	$648.42
1977-1982	117.21	$436.07

Antilock Brake Systems. Antilock brake systems were developed by the motor vehicle industry and voluntarily installed by manufacturers beginning in the mid-1980s on passenger cars and LTVs. Two different types of ABS systems were installed (rear-wheel ABS and four-wheel ABS). ABS was developed to prevent wheel lockup during hard braking on wet roads and during combination turning and braking maneuvers. When wheels lock up, the vehicle cannot respond correctly to steering maneuvers. When braking on low friction surfaces, standard brakes are not as effective in stopping the vehicle because the braking force is uniform to all wheels, even the ones that have little or no traction. ABS works by constantly measuring wheel speed; and, when it senses that a wheel is locking up, it decreases the braking force to that wheel. Rear-wheel ABS only controls the back two wheels. Four-wheel ABS also enables the driver to steer the vehicle in a controlled manner while stopping. Rear-wheel ABS was used on very few passenger cars. Many LTVs were equipped with rear-wheel ABS, and then all LTVs were changed to four-wheel ABS by MY 2004.

No type of ABS has ever been required for passenger vehicles with GVWR of 10,000 pounds or less. However, the Highway Safety Act of 1991, Section 2507 instructed NHTSA to consider requiring ABS in passenger vehicles. NHTSA published an ANPRM at the beginning of 1994 asking for information about the effectiveness and potential benefits of ABS technologies.[19] Based on responses to the 1994 ANPRM, including statistical studies by NHTSA and others that failed to show significant net benefits for voluntarily installed ABS, NHTSA issued a second ANPRM in 1996 deferring indefinitely the ABS requirement.[20] [21] [22] These studies concluded that ABS had mixed effectiveness results, and NHTSA subsequently decided not to go forth with rulemaking to require ABS for passenger vehicles.

Rear-wheel ABS was only installed on a small number of passenger cars. The only passenger cars with rear-wheel ABS[23] are 1987 thru MY 1989 Chrysler Conquest (100% have rear-wheel ABS), MY 1987 Mitsubishi Starion (72% with rear-wheel ABS) and MY 1989 Mitsubishi Starion (100% with rear-wheel ABS). The estimated sales of the Chrysler Conquest were 13,975 in MY 1987, 8,605 in MY 1988, and 4,502 in MY 1989. The estimated sales of the Mitsubishi Starion were 6,264 in MY 1987 (of which 4,510 had rear wheel ABS) and 130 vehicles in MY 1989. Combined these vehicles with rear-wheel ABS comprised 0.18 percent of MY 1987 passenger car sales, 0.08 percent in MY 1988, and 0.05 percent in MY 1989.

Four-wheel ABS was installed on an increasing number of passenger cars. Table 105-1 shows the percentage of passenger cars with four-wheel and rear-wheel ABS by model year.[24]

The major ABS components are the wheel speed sensors and rings, the control unit, the modulator unit, and the wiring harness. The wheel speed sensors and rings provide an electrical signal to the ABS controller that is proportional to the wheel speed. The ABS controller is a computer that interprets and compares the signal from all the wheel speed sensors and sends

[19] *Federal Register* 59 (January 4, 1994): 281.
[20] *Federal Register* 61 (July 12, 1996): 36698.
[21] Kahane, C. J. (1993, December). *Preliminary evaluation of the effectiveness of rear-wheel antilock brake systems for LTVs*. Washington, DC: National Highway Traffic Safety Administration. (NHTSA Docket No. 70-27-GR-026.)
[22] Kahane, C. J. (1994, December). *Preliminary evaluation of the effectiveness of antilock brake systems for passenger cars* (Report No. DOT HS 808 206). Washington, DC: National Highway Traffic Safety Administration. . Available at www-nrd.nhtsa.dot.gov/Pubs/808206.pdf
[23] Ibid.
[24] Kahane, C. J., & Dang, J. N. (2009, August). *The long-term effect of ABS in passenger cars and LTVs* (Report No. DOT HS 811 182). Washington, DC: National Highway Traffic Safety Administration. Available at www-nrd.nhtsa.dot.gov/Pubs/811182.pdf . The ABS data for passenger cars and LTVs is from a spreadsheet that created Figures 1-1 and 1-2 in this report.

control signals to the ABS modulator. The ABS modulator controls the hydraulic brake fluid pressure for each wheel. When the ABS controller interprets a signal from a wheel speed sensor as a wheel lock-up condition, a signal is sent to the modulator to rapidly pulse the hydraulic pressure at that particular wheel releasing the brake until the proper wheel speed has been restored. The wiring harness provides electrical power to the ABS controller and connects the speed sensors and the modulator to the controller.

NHTSA has estimated the weight and cost of four-wheel ABS in three different teardown studies. We will present the weight and costs for four-wheel passenger cars and LTVs together under the assumption that the weights and costs are fairly similar between passenger cars and LTVs. NHTSA also has one teardown estimate for the weight and cost of a rear-wheel ABS system.

In 1991 NHTSA analyzed the cost of seven different four-wheel ABS systems in 5 passenger cars and 2 LTVs from MYs 1988-1990.[25] Table 105-8 shows the sales-weighted average weight and consumer cost of ABS in these seven models. These are the incremental weights and costs of ABS, above and beyond the pre-ABS hydraulic brake system.

In 1994 NHTSA looked at the four-wheel ABS systems in one 1992 and one 1993 passenger car and a 1994 SUV.[26]

In 2006, NHTSA examined four-wheel ABS in 11 vehicles (5 passenger cars and 6 LTVs),[27] 9 of which were MY 2005 vehicles, one from MY 2004 and one from MY 2006. The estimates were summarized in the Final Regulatory Impact Analysis that accompanied the final rule on electronic stability control.[28] Based on the teardowns of a variety of vehicles of Asian, European, and domestic passenger cars and LTVs, it was assumed that the same cost would apply for both passenger cars and LTVs. The estimates were incremental to the hydraulic brake systems already on the vehicles. Table 105-8a summarizes these estimates and Table 105-8b provides detail for the 2004-2006 models. Antilock brakes was one of the technologies used to set the learning curve progress rates. The learning curve for four-wheel ABS was applied to the $419.89 estimate based in 2005 for all years from 1986 to 2012 with a progress rate of 0.90.

Since the rear-wheel ABS systems and the four-wheel ABS systems were essentially the same (only differing in the teardown study by the two front wheel speed sensors), we have combined the cumulative sales from both the rear-wheel and four-wheel ABS systems when using the learning curve for both the rear-wheel and four-wheel ABS systems.

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[25] Fladmark, G. L., & Khadilkar, A. V. (1991, April). *Evaluation of costs of antilock brake systems, Volumes I and II,* (Report Nos. DOT HS 809 794 and DOT HS 809 795). Washington, DC: National Highway Traffic Safety Administration, April 1991.), Docket No. 2011-0066-0028 and 0027.
[26] Fladmark, G. L., & Khadilkar, A. V. (1994, July). *Cost estimates of Head Restraints in LTVs/Vans (Volume I) and Cost Estimates of Lower Cost Antilock Brake Systems (Volume II)* (Report No. DOT HS 809 797) Washington, DC: National Highway Traffic Safety Administration, Docket No. 2011-0066-0025.
[27] Ludtke & Associates. (n.a.). *Cost and weight analysis of the combined system of electronic stability control (ESC), antilock braking system (ABS), and traction control system (TCS)*, Docket No. 2011-0066-0005.
[28] NHTSA. (2007, March). *Final Regulatory Impact Analysis, FMVSS No 126, Electronic Stability Control Systems*, Docket No. 2007-27662-0002.

Weight estimates for four-wheel antilock brake systems for passenger cars were taken from Table 105-8a using 35.29 pounds for MY 1986 to MY 1990, 23.51 pounds for MY 1992 to MY 1994, 10.70 pounds from MY 2004 to MY 2012, and interpolations with linearly decreasing weights for the years in between.

Table 105-8a
Average Weights and Costs (2012$)
Antilock Brake Systems - Four Wheel
Passenger Cars and LTVs

Model Years	Weight	Cost (2012$)
1989 - 1990	35.29	$755.40
1992 - 1994	23.51	$671.83
2004 - 2006	10.70	$419.89

Table 105-8b
MY 2004-2006
Components of Four-Wheel ABS
Passenger Cars and LTVs

	Weight	Cost (2012$)
Speed sensors	3.22	$68.85
Integrated Control Unit/ Hydraulic Control Unit	6.78	$331.04
Wires/Telltale/Hardware	0.7	$20.00
Total	10.70	$419.89

Costs and weights for rear-wheel ABS systems were taken from the same Ludtke study. Vehicles #9 and #10 in that teardown study were the same make/model one year apart, one with a rear-wheel ABS system (MY 2004) and one with a four-wheel ABS system. The estimated costs (2012 dollars) were $427.21 for the rear-wheel system and $456.55 for the four-wheel system. All of the difference in costs was made up by the additional two wheel speed sensors for the front wheels of the four-wheel system. The weights were essentially identical, with the weight for the four wheel system being slightly less (0.27 pounds), probably because it is one model year later and some weight was taken out. The electronic control system in both models were identical.

Since our average cost for the four-wheel ABS system is $419.89 (different than the cost of the particular make/model used in the rear-wheel ABS teardown study), we'll use the ratio of the rear-wheel system cost to the four-wheel system cost ($427.21/$456.55) = 0.936 times the average cost of the four-wheel system to estimate the cost of the rear-wheel ABS system or $392.91 ($419.89*0.936). This cost will be put into the learning curve for rear-wheel ABS systems based on a MY 2005 vehicle. We'll assume the same weights as assumed for the four-wheel system which change based on model years as described above.

ABS became attributable when electronic stability control (ESC) in FMVSS No. 126 was proposed because it provides the basic elements necessary for ESC to function properly. On September 18, 2006, NHTSA proposed FMVSS No. 126.[29] Thus, the baseline date is September 1, 2006, or MY 2007. Thus, the percentage of passenger cars and LTVs equipped with ABS in MY 2007 and earlier model years are considered voluntary, the MY 2007 baseline year installation rate (76.9% installation for passenger cars) is considered voluntary for all MY 2008 and later passenger cars, and the difference between the percentage of the fleet with ABS and 76.9 percent for passenger cars for MY 2008 and later are considered attributable.

On April 6, 2007, NHTSA issued FMVSS No. 126 to require ESC on passenger cars, multipurpose vehicles, trucks, and buses with a GVWR of 10,000 pounds or less: all new vehicles by MY 2012, with a phase-in comprising 55 percent of MY 2009 sales, 75 percent of MY 2010, and 95 percent of MY 2011.

Table 105-9 provides the resulting weight and cost estimates for voluntarily and attributable provided ABS by model year for passenger cars. This table includes both the four-wheel and rear-wheel systems. The few rear-wheel systems added to the average passenger car $1.85 and 0.06 pounds in MY 1987, $0.71 and 0.03 pounds in MY 1988, and $0.36 and 0.02 pounds in MY 1988. There is no need to provide a separate table to show the weight and cost after the learning curve since it is the same as the totals shown in Table 105-9. As noted, ABS provided basic components that ESC needed to function properly. One could thus consider the attributable costs of ABS in MY 2008 and later to be associated with FMVSS No. 126 rather than with FMVSS No. 105/135. We account for them here since we are separately analyzing this specific technology, but a full accounting of ESC costs would add the attributable portion of ABS to the ESC sensor costs, which are discussed later in this report.

[29] 71 FR 54712, Docket No. 2006-25801.

Table 105-9						
FMVSS No. 105/135 ABS for Passenger Cars						
Four-Wheel and Rear-Wheel Systems Combined						
Model Year	Weight (lb)			Consumer Cost (2012$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1985	0.0	0.0	0.0	$0.00	$0.00	$0.00
1986	0.6	0.0	0.6	$27.97	$0.00	$27.97
1987	1.7	0.0	1.7	$51.37	$0.00	$51.37
1988	1.8	0.0	1.8	$48.06	$0.00	$48.06
1989	2.3	0.0	2.3	$52.41	$0.00	$52.41
1990	3.9	0.0	3.9	$81.50	$0.00	$81.50
1991	5.0	0.0	5.0	$116.22	$0.00	$116.22
1992	7.6	0.0	7.6	$205.34	$0.00	$205.34
1993	9.7	0.0	9.7	$246.78	$0.00	$246.78
1994	13.0	0.0	13.0	$313.48	$0.00	$313.48
1995	12.4	0.0	12.4	$301.50	$0.00	$301.50
1996	12.1	0.0	12.1	$300.72	$0.00	$300.72
1997	11.3	0.0	11.3	$287.36	$0.00	$287.36
1998	11.2	0.0	11.2	$295.39	$0.00	$295.39
1999	11.2	0.0	11.2	$309.12	$0.00	$309.12
2000	10.0	0.0	10.0	$290.67	$0.00	$290.67
2001	9.0	0.0	9.0	$278.40	$0.00	$278.40
2002	8.3	0.0	8.3	$276.01	$0.00	$276.01
2003	6.9	0.0	6.9	$250.28	$0.00	$250.28
2004	6.6	0.0	6.6	$261.49	$0.00	$261.49
2005	6.7	0.0	6.7	$263.27	$0.00	$263.27
2006	7.7	0.0	7.7	$295.72	$0.00	$295.72
2007	8.2	0.0	8.2	$313.53	$0.00	$313.53
2008	8.2	0.3	8.6	$310.04	$12.21	$322.25
2009	8.2	0.9	9.2	$307.32	$34.47	$341.79
2010	8.2	2.2	10.4	$304.26	$81.01	$385.27
2011	8.2	2.3	10.6	$301.06	$85.56	$386.62
2012	8.2	2.5	10.7	$297.65	$89.41	$387.05

LTV Studies

Brake System Components

NHTSA extended FMVSS No. 105 (January 2, 1981 46 FR 55), effective in September 1983, for the 1984 model year pickup trucks, vans, SUVs, and other vehicle classes equipped with hydraulic brake systems. Essentially the same types of requirements that applied to passenger cars and school buses were now required for LTVs with hydraulic brake systems. Table 105-10 shows the percentage of LTVs equipped with the four countermeasures considered in this analysis, dual master cylinders, front disc brakes, power boosters, and ABS.

Table 105–10

Percentage of LTVs with Dual Master Cylinders, Front Disc Brakes, Power Boosters, and ABS by Model Year

Model Year	Dual Master Cylinder	Front Disc Brakes	Power Boosters	Four-Wheel ABS	Rear-Wheel ABS
1968	100	30	70	0	0
1969	100	30	70	0	0
1970	100	30	70	0	0
1971	100	30	70	0	0
1972	100	46	70	0	0
1973	100	64	70	0	0
1974	100	61	70	0	0
1975	100	75	70	0	0
1976	100	82	70	0	0
1977	100	87	70	0	0
1978	100	89	70	0	0
1979	100	89	70	0	0
1980	100	90	70	0	0
1981	100	85	70	0	0
1982	100	89	70	0	0
1983	100	93	70	0	0
1984	100	94	100	0	0
1985	100	97	100	0	0
1986	100	99	100	0	0
1987	100	99	100	0	15.5
1988	100	100	100	0	27.9
1989	100	100	100	0.2	52.4
1990	100	100	100	1.9	69.9
1991	100	100	100	5.4	72.4
1992	100	100	100	10.4	69.7
1993	100	100	100	29.7	53.3
1994	100	100	100	30.8	53.5
1995	100	100	100	53.3	36.3
1996	100	100	100	61.0	29.3

1997	100	100	100	59.8	31.5
1998	100	100	100	67.6	22.7
1999	100	100	100	71.5	18.4
2000	100	100	100	73.8	15.8
2001	100	100	100	81.3	7.3
2002	100	100	100	82.3	6.2
2003	100	100	100	87.2	4.3
2004	100	100	100	88.5	0
2005	100	100	100	90.3	0
2006	100	100	100	92.4	0
2007	100	100	100	94.6	0
2008	100	100	100	95.9	0
2009	100	100	100	99.4	0
2010	100	100	100	99.8	0
2011	100	100	100	100	0
2012	100	100	100	100	0

Dual Master Cylinders. FMVSS No. 105 explicitly requires a dual braking system – i.e., dual master cylinders – in all vehicles it regulates, including LTVs. Because dual master cylinders were installed in 100 percent of LTVs in MY 1967, long before they were proposed for LTVs these costs are not included in the attributable or voluntary costs of the FMVSS.

Since NHTSA has not performed any teardowns of LTVs master cylinders, we will assume the same cost for dual master cylinders in LTVs as in passenger cars (although it is conceivable that truck systems could cost more to the extent that LTVs are usually heavier vehicles than passenger cars). Table 105-3 shows the average weight and consumer cost after applying the learning curve of dual master cylinders compared to single master cylinders for passenger cars (which we believe would be the same cost for LTVs) for informational purposes.

Disc Brakes. As discussed in passenger cars above, since front disc brakes, in the long term, had lower weight and cost than drum brakes (see Table 105-4), no cost is added to this analysis for front disc brakes for LTVs.

Power Boosters. While power boosters are not explicitly required to meet FMVSS No. 105, power boosters do help vehicles to stop quickly, especially under high speed or hazardous conditions. The stopping distance requirements, in conjunction with the brake pedal apply force requirements of FMVSS No. 105, encouraged manufacturers to use power boosters. Although some LTVs without power boosters did pass the stopping distance tests, it was easier to meet them with power boosters. We decided power boosters are linked to FMVSS No. 105 because NHTSA proposed and later required a performance standard on stopping distance that resulted in the power boosters being used.

Table 105-11 shows the voluntary and attributable costs for power boosters for LTVs by year. There is no need to provide a separate table to show the weight and cost after the learning curve since it is the same as the totals shown in Table 105-11. The final rule requiring FMVSS No. 105a for passenger cars and LTVs was published September 2, 1972, (37 FR 17970). The NPRM proposing FMVSS No. 105a was issued November 11, 1970, (35 FR 17345) making the baseline date September 1, 1970, or MY 1971. Since power boosters were installed in 30 percent of all LTVs in MY 1971, they are considered voluntary for all MY 1971 and later LTVs, and the difference between the percentage of the fleet with power boosters and 30 percent for LTVs for MY 1972 and later are considered attributable.

Table 105-11

FMVSS No. 105 Power Boosters for LTVs

Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	2.8	0	2.8	$16.84	0	$16.84
1969	2.9	0	2.9	$17.27	0	$17.27
1970	3.0	0	3.0	$17.70	0	$17.70
1971	3.0	0	3.0	$18.13	0	$18.13
1972	3.1	1.7	4.8	$18.56	$9.90	$28.46
1973	3.2	3.6	6.9	$18.99	$21.53	$40.52
1974	3.3	3.4	6.7	$19.43	$20.07	$39.50
1975	3.4	5.1	8.5	$19.86	$29.79	$49.64
1976	3.5	6.0	9.5	$20.29	$35.17	$55.46
1977	2.4	4.5	6.8	$14.88	$28.27	$43.14
1978	2.4	4.6	7.0	$14.68	$28.87	$43.55
1979	2.4	4.6	7.0	$14.52	$28.55	$43.07
1980	2.4	4.7	7.1	$14.40	$28.80	$43.19
1981	2.4	4.3	6.7	$14.29	$26.21	$40.50
1982	2.4	4.6	7.0	$14.20	$27.93	$42.13
1983	2.4	5.0	7.3	$14.09	$29.60	$43.69
1984	2.4	5.0	7.4	$13.98	$29.82	$43.79
1985	2.4	5.3	7.6	$13.86	$30.95	$44.80
1986	2.4	5.4	7.8	$13.74	$31.60	$45.34
1987	2.4	5.4	7.8	$13.64	$31.37	$45.01
1988	2.4	5.5	7.9	$13.54	$31.60	$45.15
1989	2.4	5.5	7.9	$13.46	$31.41	$44.87
1990	2.4	5.5	7.9	$13.39	$31.23	$44.62
1991	2.4	5.5	7.9	$13.32	$31.09	$44.41
1992	2.4	5.5	7.9	$13.26	$30.94	$44.20
1993	2.4	5.5	7.9	$13.20	$30.79	$43.99
1994	2.4	5.5	7.9	$13.13	$30.64	$43.77
1995	2.4	5.5	7.9	$13.07	$30.49	$43.56

1996	2.4	5.5	7.9	$13.01	$30.35	$43.36
1997	2.4	5.5	7.9	$12.95	$30.22	$43.17
1998	2.4	5.5	7.9	$12.90	$30.09	$42.99
1999	2.4	5.5	7.9	$12.84	$29.95	$42.79
2000	2.4	5.5	7.9	$12.78	$29.82	$42.60
2001	2.4	5.5	7.9	$12.73	$29.70	$42.42
2002	2.4	5.5	7.9	$12.68	$29.58	$42.25
2003	2.4	5.5	7.9	$12.63	$29.47	$42.09
2004	2.4	5.5	7.9	$12.58	$29.36	$41.94
2005	2.4	5.5	7.9	$12.54	$29.25	$41.79
2006	2.4	5.5	7.9	$12.49	$29.15	$41.64
2007	2.4	5.5	7.9	$12.45	$29.06	$41.51
2008	2.4	5.5	7.9	$12.42	$28.98	$41.41
2009	2.4	5.5	7.9	$12.40	$28.93	$41.32
2010	2.4	5.5	7.9	$12.37	$28.86	$41.23
2011	2.4	5.5	7.9	$12.34	$28.80	$41.14
2012	2.4	5.5	7.9	$12.31	$28.72	$41.03

Other Brake Subsystem Components. A study was conducted on eight pre-standard (1983), and their corresponding post-standard (1984), make-model LTVs from the three major U.S. manufacturers.[30] Costs were estimated only for those subsystems of the brake systems of LTVs that were a new or changed design in 1984. The front brake pads, rear brake systems, brake power boosters, emergency brake warning switch, and variable proportioning valve subsystems of Dodge, Ford, and GM trucks were studied.

The front brake pads and rear brake shoes on the pre-standard and post-standard LTV make-models were compared. The major change was in the brake pad, shoe lining material, and size. Pre-standard pads or linings were often made from asbestos-based or inorganic materials; whereas, post-standard pads or linings are made of non-asbestos or semi-metallic materials. The elimination of the asbestos-based materials in the post-standard pads or linings was a result of the health hazards associated with its use in the manufacture of friction brake lining material and the maintenance of the brake systems. It was not a requirement of FMVSS No. 105. The semi-metallic materials were used to improve brake system fade performance and durability characteristics.

An emergency brake warning switch was added to the Ford trucks in order to comply with the brake system indicator lamp requirements. Vehicle height-sensitive variable rate proportioning valves were employed on the rear brakes to perhaps improve stopping distance performance when the LTVs were tested in a lightly loaded condition.

[30] Adams, G. J., Carlson, L. E., & Firth, B. W. (1985, August). *Cost evaluation of Federal Motor Vehicle Safety Standard 105-83*. (Report No. DOT HS 807 016). Washington, DC: National Highway Traffic Safety Administration, Docket No. 2011-0066-0042.

Table 105-12 shows the sales-weighted average weight and consumer cost of front brake pads, rear brakes, rear shoes, proportioning valves, and emergency brake warning switch for the 1983 and 1984 make-model LTVs.

TABLE 105-12
AVERAGE WEIGHT AND CONSUMER COST OF BRAKE SYSTEM COMPONENTS IN LTVS

MAKE-MODEL	COMPONENT	MODEL YEAR	WEIGHT IN POUNDS	CONSUMER COST ($2012)
Dodge 150	Front Pads	1983	1.21	$16.63
		1984	2.10	$24.94
	Rear Brakes	1983	50.29	$105.11
		1984	64.51	$119.51
	Servo	1984	8.54	$44.57
Dodge 350	Front Pads	1983	1.63	$22.30
		1984	2.81	$33.44
Dodge MPV	Variable Valve	1984	1.50	$35.12
Ford – All Trucks	Warning Light Emergency Brake	1984	0.03	$ 0.49
Ford F-150	Rear Shoes	1983	1.48	$20.32
		1984	1.77	$22.36
Ford F-250	Front Pads	1983	1.03	$14.17
		1984	1.23	$15.58
	Rear Shoes	1983	1.75	$24.01
		1984	1.80	$24.68
	Variable Valve	1984	2.90	$13.79
Ford F-350	Front Pads	1983	2.44	$33.75
		1984	2.91	$37.13
GMC 1500	Front Pads	1983	1.14	$15.58
		1984	1.36	$23.37
GMC 2500	Front Pads	1983	1.14	$15.58
		1984	1.36	$23.37
	Variable Valve	1984	3.04	$18.75
GMC 3500	Front Pads	1983	1.37	$18.84
		1984	1.64	$28.26
	Variable Valve	1984	3.04	$15.44

Except for the emergency brake warning switch in Ford trucks, NHTSA does not have strong evidence that any of these changes were directly motivated by FMVSS No. 105, or actually needed to assure compliance with the standard. Therefore, only the cost and weight of the warning light emergency brake switch is attributed to FMVSS No. 105. Since Ford accounted for 30 percent of truck sales in 1984, the 0.03 pounds and $0.49 in Ford trucks averages out to 0.01 pounds and $0.15 in all trucks. Although we don’t have data to verify this, we assume that other manufacturers provided a warning light brake switch starting in MY 1968. Thus, we assume voluntary compliance for 70 percent of the fleet from MY 1968 and 30 percent attributable to the standard from MY 1984 to MY 2012. Table 105-13 shows the average weight and consumer cost of brake system warning lights after applying the learning curve for FMVSS No. 105 in LTVs.

Table 105-13						
Average Weight and Consumer Cost Warning Light Brake Switch FMVSS No. 105 in LTVs						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	0.02	0	0.02	$0.46	0	$0.46
1969	0.02	0	0.02	$0.43	0	$0.43
1970	0.02	0	0.02	$0.41	0	$0.41
1971	0.02	0	0.02	$0.40	0	$0.40
1972	0.02	0	0.02	$0.39	0	$0.39
1973	0.02	0	0.02	$0.38	0	$0.38
1974	0.02	0	0.02	$0.38	0	$0.38
1975	0.02	0	0.02	$0.37	0	$0.37
1976	0.02	0	0.02	$0.37	0	$0.37
1977	0.02	0	0.02	$0.36	0	$0.36
1978	0.02	0	0.02	$0.36	0	$0.36
1979	0.02	0	0.02	$0.36	0	$0.36
1980	0.02	0	0.02	$0.35	0	$0.35
1981	0.02	0	0.02	$0.35	0	$0.35
1982	0.02	0	0.02	$0.35	0	$0.35
1983	0.02	0	0.02	$0.35	0	$0.35
1984	0.02	0.01	0.03	$0.34	$0.15	$0.49
1985	0.02	0.01	0.03	$0.34	$0.15	$0.49
1986	0.02	0.01	0.03	$0.34	$0.14	$0.48
1987	0.02	0.01	0.03	$0.34	$0.14	$0.48
1988	0.02	0.01	0.03	$0.33	$0.14	$0.48
1989	0.02	0.01	0.03	$0.33	$0.14	$0.47
1990	0.02	0.01	0.03	$0.33	$0.14	$0.47
1991	0.02	0.01	0.03	$0.33	$0.14	$0.47
1992	0.02	0.01	0.03	$0.33	$0.14	$0.47
1993	0.02	0.01	0.03	$0.33	$0.14	$0.46
1994	0.02	0.01	0.03	$0.32	$0.14	$0.46
1995	0.02	0.01	0.03	$0.32	$0.14	$0.46
1996	0.02	0.01	0.03	$0.32	$0.14	$0.46
1997	0.02	0.01	0.03	$0.32	$0.14	$0.46
1998	0.02	0.01	0.03	$0.32	$0.14	$0.45
1999	0.02	0.01	0.03	$0.32	$0.14	$0.45
2000	0.02	0.01	0.03	$0.32	$0.14	$0.45
2001	0.02	0.01	0.03	$0.31	$0.13	$0.45

2002	0.02	0.01	0.03	$0.31	$0.13	$0.45
2003	0.02	0.01	0.03	$0.31	$0.13	$0.45
2004	0.02	0.01	0.03	$0.31	$0.13	$0.44
2005	0.02	0.01	0.03	$0.31	$0.13	$0.44
2006	0.02	0.01	0.03	$0.31	$0.13	$0.44
2007	0.02	0.01	0.03	$0.31	$0.13	$0.44
2008	0.02	0.01	0.03	$0.31	$0.13	$0.44
2009	0.02	0.01	0.03	$0.31	$0.13	$0.44
2010	0.02	0.01	0.03	$0.31	$0.13	$0.44
2011	0.02	0.01	0.03	$0.31	$0.13	$0.44
2012	0.02	0.01	0.03	$0.30	$0.13	$0.44

Antilock Brake Systems. Starting in MY 1987, ABS systems controlling only the rear wheels were installed on a growing percentage of LTVs rising to 72 percent in MY 1991. Rear-wheel ABS was intended to reduce rear wheel lockup and yawing. Many light truck crashes involved loss of directional control during braking, and rear wheel ABS reduced loss of control on straight line braking tests. Rear-wheel ABS was an important first step for light trucks, culminating with large safety benefits from electronic stability control. A 1993 study by NHTSA[31] found that rear-wheel ABS significantly reduced the rate of non-fatal run-off-road crashes for all types of LTVs. The accident reductions mostly did not carry over to fatal run-off-road crashes and little or no reduction could be found for multi-vehicle crashes. Since MY 1993, it became increasingly common for ABS systems to control all four wheels on LTVs, similar to passenger cars. In 2009, NHTSA issued an evaluation based on GES data (a national sample) from 1995 to 2007 and comprising a list of LTV make-models that had been equipped with rear-wheel only ABS at some point. The follow-up study shows negligible effect for rear-wheel ABS overall, and it no longer shows a statistically significant effect in run-off-road crashes or in any specific type of crashes, such as rollovers.[32] For this analysis, we consider rear wheel ABS as a voluntary safety measure. NHTSA never proposed it; however it did appear to provide safety for drivers of LTVs.

ABS provided basic components that were needed by electronic stability control (ESC) in FMVSS No. 126 to function properly. Even though ABS is not a requirement for FMVSS No. 105/135 it is discussed and analyzed here. On September 18, 2006, NHTSA proposed FMVSS No. 126.[33] Thus, the baseline date is September 1, 2006, or MY 2007. The percentage of LTVs equipped with ABS in MY 2007 and earlier model years are considered voluntary, the MY 2007 baseline year (94.6% installation for LTVs) is considered voluntary for all MY 2008 and later LTVs, and the difference between the percentage of the fleet with ABS and 94.6 percent for LTVs for MY 2008 and later are considered attributable.

[31] Kahane, C. J. (1993, December). *Preliminary evaluation of the effectiveness of rear-wheel antilock brake systems for light trucks* (Unnumbered report). Washington, DC: National Highway Traffic Safety Administration. Available at https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/7027GR
[32] Kahane, C. J., & Dang, J. N. (2009, August). *The long-term effect of ABS in passenger cars and LTVs* (Report No. DOT HS 811 182). Washington, DC: National Highway Traffic Safety Administration. Available at www-nrd.nhtsa.dot.gov/Pubs/811182.pdf
[33] 71 FR 54712, Docket No. 2006-25801.

On April 6, 2007, NHTSA issued FMVSS No. 126 to require ESC on passenger cars, multipurpose vehicles, trucks, and buses with a GVWR of 10,000 pounds or less: all new vehicles by MY 2012, with a phase-in comprising 55 percent of MY 2009 sales, 75 percent of MY 2010, and 95 percent of MY 2011.

The costs and weights per vehicle are the same for passenger cars and LTVs for both the four-wheel ABS systems and the rear-wheel ABS systems (see the discussion in the passenger car ABS section). For LTVs we will present separate tables for four-wheel ABS systems and for rear-wheel ABS systems. Table 105-14 provides the resulting weight and cost estimates for voluntarily and attributable provided four-wheel ABS by model year for LTVs and Table 105-15 provides the results for rear-wheel ABS systems. There is no need to provide a separate table to show the weight and cost after the learning curve since it is the same as the totals shown in Tables 105-14 and 105-15. As noted, ABS provided basic components necessary for ESC to function properly. One could thus consider the attributable costs of ABS in MY 2008 and later to be associated with FMVSS No. 126 rather than with FMVSS No. 105/135. We account for them here since we are separately analyzing this specific technology, but a full accounting of ESC costs would add the attributable portion of ABS to the ESC sensor costs, which are discussed later in this report.

Table 105-14						
FMVSS No. 105/135 Four-Wheel ABS for LTVs						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1988	0.0	0.0	0.0	$0.00	$0.00	$0.00
1989	0.1	0.0	0.1	$1.63	$0.00	$1.63
1990	0.7	0.0	0.7	$13.95	$0.00	$13.95
1991	1.6	0.0	1.6	$36.92	$0.00	$36.92
1992	2.4	0.0	2.4	$66.32	$0.00	$66.32
1993	7.0	0.0	7.0	$177.90	$0.00	$177.90
1994	7.2	0.0	7.2	$173.97	$0.00	$173.97
1995	11.8	0.0	11.8	$287.48	$0.00	$287.48
1996	12.8	0.0	12.8	$316.27	$0.00	$316.27
1997	11.8	0.0	11.8	$299.90	$0.00	$299.90
1998	12.4	0.0	12.4	$328.97	$0.00	$328.97
1999	12.2	0.0	12.2	$337.95	$0.00	$337.95
2000	11.7	0.0	11.7	$339.96	$0.00	$339.96
2001	11.8	0.0	11.8	$366.24	$0.00	$366.24
2002	10.9	0.0	10.9	$363.45	$0.00	$363.45
2003	10.4	0.0	10.4	$378.25	$0.00	$378.25
2004	9.5	0.0	9.5	$377.52	$0.00	$377.52
2005	9.7	0.0	9.7	$379.16	$0.00	$379.16
2006	9.9	0.0	9.9	$382.16	$0.00	$382.16
2007	10.1	0.0	10.1	$385.70	$0.00	$385.70
2008	10.1	0.1	10.3	$381.40	$5.44	$386.84
2009	10.1	0.5	10.6	$378.05	$19.17	$397.23
2010	10.1	0.6	10.7	$374.29	$20.77	$395.05
2011	10.1	0.6	10.7	$370.35	$21.14	$391.49
2012	10.1	0.6	10.7	$366.15	$20.90	$387.05

Table 105-15						
FMVSS No. 105/135 Rear-Wheel ABS for LTVs						
Model	Weight (lb)			Consumer Cost (2012$)		
Year	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1986	0.0	0.0	0.0	0.0	0.0	0.0
1987	5.5	0.0	5.5	159.6	0.0	159.6
1988	9.8	0.0	9.8	242.4	0.0	242.4
1989	18.5	0.0	18.5	398.8	0.0	398.8
1990	24.7	0.0	24.7	480.2	0.0	480.2
1991	21.3	0.0	21.3	463.1	0.0	463.1
1992	16.4	0.0	16.4	415.9	0.0	415.9
1993	12.5	0.0	12.5	298.7	0.0	298.7
1994	12.6	0.0	12.6	282.8	0.0	282.8
1995	8.1	0.0	8.1	183.2	0.0	183.2
1996	6.1	0.0	6.1	142.2	0.0	142.2
1997	6.2	0.0	6.2	147.8	0.0	147.8
1998	4.2	0.0	4.2	103.4	0.0	103.4
1999	3.1	0.0	3.1	81.4	0.0	81.4
2000	2.5	0.0	2.5	68.1	0.0	68.1
2001	1.1	0.0	1.1	30.8	0.0	30.8
2002	0.8	0.0	0.8	25.6	0.0	25.6
2003	0.5	0.0	0.5	17.5	0.0	17.5
2004	0.0	0.0	0.0	0.0	0.0	0.0
2005	0.0	0.0	0.0	0.0	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	0.0	0.0	0.0	0.0
2009	0.0	0.0	0.0	0.0	0.0	0.0
2010	0.0	0.0	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0	0.0	0.0

FMVSS No. 106, Brake hoses

FMVSS No. 106 took effect on January 1, 1968, and specifies labeling and performance requirements for motor vehicle brake hoses, brake hose assemblies, and brake hose end fittings. The purpose of this standard is to reduce deaths and injuries occurring because of brake system failure from pressure or vacuum loss due to hose or hose assembly rupture. The standard applies to passenger cars, multipurpose passenger vehicles, trucks, all LTVs, buses, trailers, and motorcycles and to hydraulic, air, and vacuum brake hoses, brake hose assemblies, and brake hose end fittings for use in those vehicles. No cost studies of brake hoses have been performed, and none are planned by NHTSA.

FMVSS No. 107 - Does not currently exist

FMVSS No. 108, Lamps, reflective devices, and associated equipment

FMVSS No. 108 took effect on January 1, 1968, for vehicles with 80 or more inches of overall width and January 1, 1969, for all other vehicles. It specifies the requirements for original and replacement lamps, reflective devices, and associated equipment. The purpose of this standard is to reduce traffic accidents, deaths, and injuries by providing adequate illumination of the roadway and by enhancing the conspicuity of motor vehicles on the public roads so that their presence is perceived and their signals understood in daylight, darkness, or other conditions of reduced visibility. The standard applies to:

- passenger cars, multipurpose passenger vehicles, trucks, buses, trailers, and motorcycles
- retro reflective sheeting and reflex reflectors; and
- lamps, reflective devices, and associated equipment for replacement of like equipment on vehicles to which this standard applies.

FMVSS No. 108 has been amended many times; however, the most important regulations have been (1) the original standard, (2) the side marker lamp requirement, (3) the center high mounted stop lamp requirement, and (4) the retroreflective tape requirement for heavy trailers. While this standard covers all types of lighting and reflective devices, side marker lamps and CHMSL are the only lighting developments whose cost may be attributable to FMVSS No. 108 for passenger cars and LTVs.

Daytime running lights are not included in this analysis. In 1990 GM petitioned NHTSA to allow DRL on new cars and LTVs sold in the United States. On January 11, 1993, NHTSA amended FMVSS No. 108 to allow DRL on new vehicles. They began to appear on some GM vehicles in MY 1995 and on all of them by MY 1997. During MY 1997 to 2005, 25 to 30 percent of new cars and LTVs were DRL-equipped. GM again petitioned in 2001, this time to mandate rather than merely allow DRL on new vehicles. In 2008 NHTSA evaluated the crash-reducing effectiveness of DRL based on 2000-to-2005 data from FARS and from 9 State crash files. None of the analyses showed a statistically significant effect for DRL; the observed overall effect was a non-significant 0.1 percent reduction of daytime involvements in two-vehicle crashes. On June 29, 2009, NHTSA denied the GM petition to mandate DRL in the United States.[34] NHTSA has not performed a cost teardown study on DRL. Since DRL have not been shown to be effective safety equipment, they are not considered voluntary equipment in this analysis.

[34] Wang, J. (2008, September). *The effectiveness of daytime running lights for passenger vehicles* (Report No. DOT HS 811 029). Washington, DC: National Highway Traffic Safety Administration. Available at www-nrd.nhtsa.dot.gov/Pubs/811029.pdf; *Federal Register* 58 (January 11, 1993): 3500, 74 (June 29, 2009): 30993.

Side Marker Lamps. Prior to 1968 passenger cars did not have side marker lamps. That made it very difficult to see them from the side at night, especially when they crossed into intersections or pulled out of a driveway. Beginning with the 1970 model year, FMVSS No. 108 required a red lamp (as far to the rear of the vehicle as practicable) and an amber lamp (as far to the front of the vehicle as practicable) on each side of the vehicle. Thus, four lamp/reflectors were required for all passenger cars and LTVs.

The final rule that included side marker lamps was published in the Federal Register on February 3, 1967, (32 FR 2414) and was applicable to side marker lamps for both passenger cars and LTVs. The NPRM was published December 3, 1966, (35 FR 15212) making the baseline date September 1, 1966, or MY 1967. We believe that all MY 1968 passenger cars and LTVs had side marker lamps and since no passenger cars or LTVs had them in the baseline year MY 1967, all of the side marker lamps in MY 1968 are attributable to the standard.

A study of the side marker lamps or reflectors was conducted on twenty-six make-model passenger cars representing pre-standard (MY 1969), post-standard (MY 1970), and later-model systems (MY 1979 - MY 1981).[35] [36] Side marker lamps evolved over time. The sales-weighted average for the weight and consumer cost of the pre-standard 1969 model year passenger cars was calculated at 1.46 pounds and $25.80 in 2012 dollars, which is attributed to the standard for MYs 1968-69. Implementation of the side marker lamps in the post-standard 1970 model year passenger cars increased the weight to 1.95 pounds and the consumer cost to $36.23 in 2012 dollars, which is attributed to the standard for MYs 1970-1978. The later model (1979-1981) side marker lamps in passenger cars decreased in weight to 1.30 pounds and increased in consumer cost to $38.43 in 2012 dollars. The last cost estimate from the teardown study was for 1981 models. The learning curve was thus applied to all costs from 1982 to 2012.

NHTSA has no cost teardown studies of side marker lamps for LTVs, but assumes they are the same weight and cost as estimated for passenger cars.

Table 108-1 shows the average weight and consumer cost of side marker lamps attributable to FMVSS No. 108 in passenger cars and LTVs. There is no need to provide a separate table to show the weight and cost after the learning curve since it is the same as the totals shown in Table 108-1.

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[35] Harvey, M. R., Lesczhik, J. A., & McLean, R. F. (1979, November). *Cost evaluation for nine Federal Motor Vehicle Standards, Volume II, FMVSS 108* (Report No. DOT HS 805 316), Washington, DC: National Highway Traffic Safety Administration, Docket No. 2011-0066-0076.

[36] Gladstone, R., Harvey, M. R., & Lesczhik, J. A. (1982, March). *Estimation of the Weight and Consumer Price of Late Model Vehicle Components Relating to the Implementation of FMVSS 108, 202, 208, and 214* (Report No. DOT HS 806 257). Washington, DC: National Highway Traffic Safety Administration, Docket No. 2011-0066-0066.

Table 108-1						
FMVSS No. 108 Side Marker Lamps for Passenger Cars and LTVs						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	0.0	1.5	1.5	$0.00	$25.80	$25.80
1969	0.0	1.5	1.5	$0.00	$25.80	$25.80
1970	0.0	2.0	2.0	$0.00	$36.23	$36.23
1971	0.0	2.0	2.0	$0.00	$36.23	$36.23
1972	0.0	2.0	2.0	$0.00	$36.23	$36.23
1973	0.0	2.0	2.0	$0.00	$36.23	$36.23
1974	0.0	2.0	2.0	$0.00	$36.23	$36.23
1975	0.0	2.0	2.0	$0.00	$36.23	$36.23
1976	0.0	2.0	2.0	$0.00	$36.23	$36.23
1977	0.0	2.0	2.0	$0.00	$36.23	$36.23
1978	0.0	2.0	2.0	$0.00	$36.23	$36.23
1979	0.0	1.3	1.3	$0.00	$38.43	$38.43
1980	0.0	1.3	1.3	$0.00	$38.43	$38.43
1981	0.0	1.3	1.3	$0.00	$38.43	$38.43
1982	0.0	1.3	1.3	$0.00	$37.94	$37.94
1983	0.0	1.3	1.3	$0.00	$37.69	$37.69
1984	0.0	1.3	1.3	$0.00	$37.41	$37.41
1985	0.0	1.3	1.3	$0.00	$37.13	$37.13
1986	0.0	1.3	1.3	$0.00	$36.86	$36.86
1987	0.0	1.3	1.3	$0.00	$36.63	$36.63
1988	0.0	1.3	1.3	$0.00	$36.40	$36.40
1989	0.0	1.3	1.3	$0.00	$36.21	$36.21
1990	0.0	1.3	1.3	$0.00	$36.03	$36.03
1991	0.0	1.3	1.3	$0.00	$35.88	$35.88
1992	0.0	1.3	1.3	$0.00	$35.73	$35.73
1993	0.0	1.3	1.3	$0.00	$35.57	$35.57
1994	0.0	1.3	1.3	$0.00	$35.41	$35.41
1995	0.0	1.3	1.3	$0.00	$35.26	$35.26
1996	0.0	1.3	1.3	$0.00	$35.11	$35.11
1997	0.0	1.3	1.3	$0.00	$34.97	$34.97
1998	0.0	1.3	1.3	$0.00	$34.83	$34.83
1999	0.0	1.3	1.3	$0.00	$34.69	$34.69
2000	0.0	1.3	1.3	$0.00	$34.55	$34.55
2001	0.0	1.3	1.3	$0.00	$34.41	$34.41
2002	0.0	1.3	1.3	$0.00	$34.28	$34.28
2003	0.0	1.3	1.3	$0.00	$34.16	$34.16

2004	0.0	1.3	1.3	$0.00	$34.05	$34.05
2005	0.0	1.3	1.3	$0.00	$33.93	$33.93
2006	0.0	1.3	1.3	$0.00	$33.82	$33.82
2007	0.0	1.3	1.3	$0.00	$33.72	$33.72
2008	0.0	1.3	1.3	$0.00	$33.64	$33.64
2009	0.0	1.3	1.3	$0.00	$33.58	$33.58
2010	0.0	1.3	1.3	$0.00	$33.51	$33.51
2011	0.0	1.3	1.3	$0.00	$33.44	$33.44
2012	0.0	1.3	1.3	$0.00	$33.36	$33.36

Center High Mounted Stop Lamps. NHTSA amended FMVSS No. 108 on October 18, 1983, (48 FR 48235) to require CHMSL on new passenger cars, effective September 1, 1985. CHMSL were standard equipment on all MY 1986 cars; also on 1985 Cadillacs models comprising 2.7 percent of the passenger car fleet.[37] The purpose of CHMSL is to safeguard a vehicle from being struck in the rear by another vehicle. When the brakes are applied, the CHMSL sends a conspicuous signal to drivers of following vehicles that they must slow down. Since nearly two-thirds of all rear impact crashes involve pre-impact braking by the lead vehicle, the CHMSL can be a significant countermeasure to deter rear-impact crashes of all types.

A study was conducted on 30 passenger cars of MYs 1986 and 1987 to determine the weight and consumer cost of CHMSL.[38] [39] The sales-weighted average for the weight and consumer cost for the 1986 and 1987 model year passenger cars were calculated at 0.85 pounds and $12.02 in 2012 dollars. Because NHTSA has not performed teardown analyses for these systems on LTVs, and because they are similar to the systems on passenger cars, we will assume the same costs on LTVs as on passenger cars.

The NPRM for passenger cars CHMSL was published in the Federal Register on January 8, 1981 (46 FR 2132) making the baseline date September 1, 1980, or MY 1981. Since no passenger cars had CHMSL in MY 1981, all MY 1985 and later CHMSL are attributable to the standard.

An evaluation of CHMSL[40] provided make/model information of LTVs that had CHMSL for MYs 1991 to 1993. This data was combined with Ward's Automotive Yearbook sales data to determine the percentage of MY 1991 to 1993 LTVs with CHMSL. All LTVs had CHMSL in MY 1994.

[37] Based on *MVMA Motor Vehicles Facts and Figures '87*, Page 15, (298,762 Cadillac sales/11,042,115 passenger car sales).
[38] Carlson, L. E., & Leonard, P. (1986, May). *Cost evaluation of Federal Motor Vehicle Safety Standard 108 and 207* (Report No. DOT HS 807 017) Washington, DC: National Highway Traffic Safety Administration, Docket No. 2011-0066-0041.
[39] Khadilkar, A. V., & Fladmark, G. L. (1988, November). *Cost estimates of center high-mounted stop lamps and passenger car red/amber rear turn signal lamps* (Report No. DOT HS 809 793). Washington, DC: National Highway Traffic Safety Administration, Docket No. 2011-0066-0029.
40 Kahane, C. J., & Hertz, E. (1998, March). *The long-term effectiveness of center high mounted stop lamps in passenger cars and light trucks.* (Report No. DOT HS 808 696). Washington, DC: National Highway Traffic Safety Administration. Available at www-nrd.nhtsa.dot.gov/Pubs/808696.pdf

The final rule extending CHMSL to LTVs was published on April 19, 1991, (56 FR 16015) and took effect on September 1, 1993. The NPRM was published in the Federal Register on May 31, 1990, (55 FR 22039) making the baseline date September 1, 1989, or MY 1990. Since no LTVs had CHMSL in MY 1990, all MY 1991 and later CHMSL in LTVs are considered attributable to the standard.

Table 108-2 shows the average weight and consumer cost of CHMSL attributable to FMVSS No. 108 in both passenger cars and LTVs. The cost per vehicle per model year is the same; however, the percentage of the fleet with CHMSL is different before the effective dates of the standard (MY 1985 for passenger cars and MYs 1991-1993 for LTVs). There is no need to provide a separate table to show the weight and cost after the learning curve since it is the same as the totals shown in Table 108-2 for passenger cars.

Table 108-2
Average Weight and Cost of
CHMSL Attributable to FMVSS No. 108
Passenger Cars and LTVs

Model Year	PC % of fleet	LTV % of fleet	PC Weight	PC Cost $2012	LTV Weight	LTV Cost $2012
1984	0	0	0	$0.00	0	0
1985	2.7	0	0.02	$0.48	0	0
1986	100	0	0.85	$12.02	0	0
1987	100	0	0.85	$11.26	0	0
1988	100	0	0.85	$10.81	0	0
1989	100	0	0.85	$10.51	0	0
1990	100	0	0.85	$10.30	0	0
1991	100	15.6	0.85	$10.13	0.13	$1.58
1992	100	32.7	0.85	$9.97	0.28	$3.26
1993	100	42.3	0.85	$9.82	0.36	$4.16
1994	100	100	0.85	$9.65	0.85	$9.65
1995	100	100	0.85	$9.51	0.85	$9.51
1996	100	100	0.85	$9.38	0.85	$9.38
1997	100	100	0.85	$9.27	0.85	$9.27
1998	100	100	0.85	$9.17	0.85	$9.17
1999	100	100	0.85	$9.07	0.85	$9.07
2000	100	100	0.85	$8.98	0.85	$8.98
2001	100	100	0.85	$8.90	0.85	$8.90
2002	100	100	0.85	$8.83	0.85	$8.83
2003	100	100	0.85	$8.76	0.85	$8.76
2004	100	100	0.85	$8.70	0.85	$8.70

2005	100	100	0.85	$8.64	0.85	$8.64
2006	100	100	0.85	$8.59	0.85	$8.59
2007	100	100	0.85	$8.54	0.85	$8.54
2008	100	100	0.85	$8.51	0.85	$8.51
2009	100	100	0.85	$8.48	0.85	$8.48
2010	100	100	0.85	$8.45	0.85	$8.45
2011	100	100	0.85	$8.41	0.85	$8.41
2012	100	100	0.85	$8.38	0.85	$8.38

Headlamp Concealment Devices. Headlamp concealment devices were a popular design feature for passenger cars during the 1960s. These devices were primarily cosmetic; however, an unsafe driving situation could arise if the concealment devices were frozen shut when headlamps were needed. FMVSS No. 112 took effect on January 1, 1969, and required that the devices remain fully open when there is a power loss or system failure, or that they be manually operable without the use of tools. In addition, the device could not be involved in either the mounting or the aiming of the headlamps. FMVSS No. 112 was canceled on October 24, 1996, and the requirements were incorporated into FMVSS No. 108 (Lamps, Reflective Devices, and Associated Equipment under Section 12).

A study conducted on four make-model passenger cars, representing pre-standard and post-standard systems, indicated that the headlamp concealment devices met the requirements of the standard before its effective date.[41] While there were minor changes in the headlamp concealment devices between 1966 and 1969, none of the changes were related to the standard. The arithmetic average for the weight and consumer cost of headlamp concealment devices for the pre-standard MY 1966 passenger cars was calculated at 12.20 pounds and $141.25 in 2012 dollars. By 1969, the average weight for the post-standard passenger cars had increased to 14.01 pounds while the consumer cost decreased to $121.71 in 2012 dollars. The main reason for the decreased cost was the change in operating system from an electrical system to a vacuum system for reasons unrelated to the regulation.

The final rule on headlamp concealment devices (FMVSS No. 112) was published in the Federal Register on April 27, 1968, (33 FR 6465) for passenger cars and LTVs. The NPRM was published on December 28, 1967, (32 FR 20865) making the baseline date September 1, 1967, or MY 1968. No cost is attributed to FMVSS No, 108 because all concealment devices met the requirements of the standard long before its baseline date of MY 1968, and the changes made did not appear to relate to the standard.

Other Lighting System Developments. Technological advances have resulted in changes to vehicle lighting systems. Manufacturers are offering quartz-halogen headlamps, composite headlamps with replaceable bulbs, high intensity discharge lights, light-emitting diode lights,

[41] Adams, G. J., Carlson, L. E., Hoffman, A. G., & Shideh, S. (1983, November). *Cost evaluation of Federal Motor Vehicle Safety Standards 111, 112, 118, and 124* (Report No. DOT HS 806 774). Washington, DC: National Highway Traffic Safety Administration, Docket No. 2011-0066-0049.

and daytime running lamps. Since FMVSS No. 108 did not require these changes, no cost studies have been performed, and none are planned by this agency.

FMVSS No. 109, New pneumatic and certain specialty tires

FMVSS No. 109 took effect on January 1, 1968, and specifies tire dimensions and laboratory test requirements for bead unseating resistance, strength, endurance, and high-speed performance; defines tire load rating; and specifies labeling requirements for passenger car tires. This standard applies to new pneumatic radial tires for use on passenger cars manufactured after 1948 and before 1975, new pneumatic bias ply tires, T-type spare tires, ST, FI, and 8-12 rim diameter and below tires for use on passenger cars manufactured after 1948. For new light vehicles (since they all use radial tires), FMVSS No. 109 was superseded by FMVSS No. 139. FMVSS No. 139 applies to new pneumatic radial tires for use on motor vehicles (other than motorcycles and low speed vehicles) that have a gross vehicle weight rating (GVWR) of 10,000 pounds or less and that were manufactured after 1975. Thus, FMVSS No. 139 applies to passenger car and LTV tires. No cost studies of new pneumatic tires related to FMVSS No. 109 have been performed, and none are planned by this agency.

FMVSS No. 110, Tire selection and rims and motor home/recreation vehicle trailer load carrying capacity information for motor vehicles with a GVWR of 4,536 kilograms (10,000 pounds) or less

FMVSS No. 110 took effect on April 1, 1968, and specifies requirements for original equipment tire and rim selection on new passenger cars to prevent tire overloading. These include placard requirements relating to load distribution as well as rim performance requirements under conditions of rapid tire deflation. This standard also applies to non-pneumatic spare tire assemblies for use on passenger cars. No cost studies have been performed, and none are planned by this agency.

FMVSS No. 111, Rear visibility

Mirrors

FMVSS No. 111 took effect on January 1, 1968, and specifies requirements for the performance and location of inside and outside rearview mirrors. The purpose of this standard is to reduce the number of deaths and injuries that occur when the driver of a motor vehicle does not have a clear and reasonably unobstructed view to the rear. This standard applies to passenger cars, multi-purpose passenger vehicles, trucks, (all LTVs) buses, school buses, and motorcycles. Furthermore, FMVSS No. 111 requires passenger cars to have a mounting system for the inside rearview mirror that would break away upon impact, and an outside rearview mirror. The purpose of breakaway mirrors is to reduce fatalities and injuries in frontal collisions to front seat occupants who contact the rearview mirror.

A study of inside rearview mirrors was conducted on sixteen pre-standard make-model passenger cars and their corresponding post-standard and trend systems.[42] Because most States required outside rearview mirrors before the implementation of FMVSS No. 111, they were not in the

[42] Adams, Carlson, Hoffman, & Shideh, DOT HS 806 7741983, Docket No. 2011-0066-0049.

study. The sales-weighted average for the weight and consumer cost of the pre-standard MY 1966 passenger cars was calculated at 0.97 pounds and $9.47 in 2012 dollars. Implementation of the inside rearview mirrors in the post-standard 1968 model year passenger cars increased the weight to 1.12 pounds and the consumer cost to $13.34. However, estimation of the weight and consumer price in the 1982 model year passenger cars indicated a decrease in weight to 0.71 pounds and in consumer cost to $8.27 in 2012 dollars. Since the average weight and consumer cost decreased by 0.26 pounds and $1.20 in 2012 dollars between the pre-standard and long-term trend results, no cost is attributed to FMVSS No. 111.

Rear Visibility Requirements

To reduce the risk of backover crashes involving children, the elderly, and other pedestrians, NHTSA issued a final rule on April 7, 2014, (79 FR 19178) to expand the rear field of view for all passenger cars, LTVs, buses, and low speed vehicles with a gross vehicle weight of 10,000 pounds or less. The rule expands the rear field of view to detect a 10-foot wide by 20-foot long zone directly behind the vehicle. The compliance effective date begins on May 1, 2016, requiring 10 percent of vehicles manufactured from May 1, 2016, to before May 1, 2017, to comply, 40 percent of vehicles manufactured from May 1, 2017, to before May 1, 2018, to comply and full compliance (100%) of vehicles manufactured on or after May 1, 2018. The final rule carries out the mandate of the Cameron Gulbranson Kids Transportation Act of 2007. The current technology being used that would meet the final rule is a camera system with a video screen that displays an image to the driver of what is directly behind the vehicle.

The NPRM was published on December 7, 2010, (75 FR 76186), making the baseline date September 1, 2010, or MY 2011. Thus, the percentage of passenger cars and LTVs equipped with a rear visibility camera in MY 2011 and earlier model years are considered voluntary, the MY 2011 baseline year installation rate is considered voluntary for MY 2012, and the difference between the percentage of the fleet with rear visibility cameras in MY 2011 and MY 2012 are considered attributable for MY 2012. A percentage of the fleet had met the essential requirements of the final rule and will be included in this report as a voluntary or attributable cost.

The cost teardown study[43] included costs of 5 ultrasonic sensor systems and 3 MY 2010 camera systems. Based on research and cost benefit analysis, NHTSA determined that ultrasonic sensor systems were not good enough at detecting pedestrians and that MY 2010 camera systems had the basic components that could be slightly altered to meet the final rule's requirements. Some camera systems did not meet the time requirements for the screen to show the image after putting the vehicle in reverse. This is a software change that given time will be a no-cost item. However, these vehicles had all of the essential cost items, camera, video screen, computer, wiring, etc.

For this analysis, we do not consider ultrasonic sensors as a baseline system that was replaced by a camera system or as a safety system that was voluntarily supplied. Both ultrasonic systems and camera systems were being marketed at the same time, with the ultrasonic sensor system being marketed as more of a parking aid than as a safety system. Since the final rule was not yet issued by MY 2012, manufacturers were not replacing ultrasonic sensor systems with camera systems.

[43] Ludtke & Associates, 2010, Docket No. 2011-0066-0010.

The ultrasonic sensor systems have not been evaluated by NHTSA to determine if they provided a safety benefit.

There would be a lower cost ($53.85) and weight (0.26 pounds) for a make-model that already had a navigation system (thus including the video screen) before adding the camera, computer, and wiring. For this analysis, the MY 2011 baseline year installations of cameras and navigation systems were examined to determine a baseline cost. Table 111-1 shows the percentage of the fleet equipped with camera and navigation systems used in this analysis. Table 111-1 is based on data collected for the Final Regulatory Impact Analysis – Backover Crash Avoidance Technologies, FMVSS No. 111.[44] Starting in MY 2006, there were more navigation systems than camera systems. By the baseline year of MY 2011, the percentage of the fleet with camera systems was very close to the percentage of the fleet with navigation systems. In essence, what we believed happened is that most of those make/models with navigation systems added a camera system. For this analysis we have defined the MY 2011 baseline as vehicles with the camera system and not consider the few models that might have had a navigation system without a camera system. Since this analysis only carries through MY 2012, and most of those make/models that had a navigation system in MY 2011 without a camera system did not introduce a camera system in MY 2012, the navigation system really isn't a baseline cost for a noticeable percentage of MY 2012 vehicles.

Table 111-1
FMVSS No. 111 Percentage of Fleet Equipped

	Cameras		Navigation System	
Model Year	**Passenger Cars**	**LTVs**	**Passenger Cars**	**LTVs**
2006	0	0	7	8
2007	0	0	7	13
2008	1.45	17.01	8	16
2009	1.37	19.28	8	16
2010	3.27	25.00	9	18
2011	11.58	24.97	11	23
2012	18.02	25.53	14	26

Based on a MY 2010 camera system with a 130-degree lens, computer, a display on the dash or in the mirror, and wiring to the system the estimated consumer cost is $165.48 in 2012 dollars and the added weight is 4.46 pounds.[45] NHTSA believes that the weight and cost for a camera system are the same for both passenger cars and LTVs.

[44] NHTSA. (2014, March). Final Regulatory Impact Analysis – Backover Crash Avoidance Technologies, FMVSS No. 111, Docket No. 2010-0162-0255.

[45] Ibid, pg. 73, Table VI-4, $159.50 in 2010 dollars brought up to $165.48 in 2012 dollars. Weight is derived from the same table, in some cases averaging the weights shown as follows (in pounds): camera 0.111, wiring 0.028, circuit board 0.117, display 1.268, hardware 2.935, = 4.46 pounds. Optical drives were assumed to be unnecessary

The initial cost was derived using MY 2010 vehicles, Table 111-2 shows the consumer cost per vehicle after applying the learning curve to MY 2008 to MY 2012 and weight per vehicle. Table 111-3 shows the distribution between voluntary and attributable costs for passenger cars by model year. Table 111-4 shows the distribution between voluntary and attributable costs for LTVs by model year.

Table 111-2
Average Weight (lb) and Cost (2012$) after
Learning Curve for Rear Visibility Cameras for FMVSS No. 111
Passenger Cars and LTVs

Model Year	PC Weight	PC Cost	LTV Weight	LTV Cost
2008	4.46	$187.32	4.46	$187.32
2009	4.46	$175.43	4.46	$175.43
2010	4.46	$165.48	4.46	$165.48
2011	4.46	$157.46	4.46	$157.46
2012	4.46	$150.89	4.46	$150.89

Table 111-3
FMVSS No. 111 Rear Visibility Cameras for Passenger Cars

Model Year	Weight (lb)			Consumer Cost (2012$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2007	0.0	0.0	0.0	$0.00	$0.00	$0.00
2008	0.1	0.0	0.1	$2.71	$0.00	$2.71
2009	0.1	0.0	0.1	$2.41	$0.00	$2.41
2010	0.1	0.0	0.1	$5.41	$0.00	$5.41
2011	0.5	0.0	0.5	$18.24	$0.00	$18.24
2012	0.5	0.3	0.8	$17.48	$9.71	$27.19

for a rear visibility system without a navigation system.

Table 111-4						
FMVSS No. 111 Rear Visibility Cameras for LTVs						
Model Year	Weight (lb)			Consumer Cost (2012$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2007	0.0	0.0	0.0	$0.00	$0.00	$0.00
2008	0.8	0.0	0.8	$31.86	$0.00	$31.86
2009	0.1	0.0	0.1	$33.83	$0.00	$33.83
2010	0.1	0.0	0.1	$41.36	$0.00	$41.36
2011	0.5	0.0	0.5	$39.31	$0.00	$39.31
2012	0.5	0.3	0.8	$37.67	$0.85	$38.53

FMVSS No. 112 – [Does not currently exist, FMVSS No. 112 was Headlamp Concealment Devices standard which has been moved and is analyzed as part of FMVSS No. 108.]

FMVSS No. 113, Hood latch system

FMVSS No. 113 took effect on January 1, 1969, and specifies the requirement for providing a hood latch system or hood latch systems. Each hood must be provided with a hood latch system, and a hood that opens from the front must be provided with a second latch position on the hood latch system or with a second hood latch system. The purpose of the standard is to prevent the incidence of hoods flying open and partially or completely obstructing the driver's view through the windshield while the vehicle is moving. This standard applies to passenger cars, multipurpose passenger vehicles, trucks, (all LTVs) and buses.

The final rule was published in the Federal Register on April 27, 1968, (33 FR 6465) for passenger cars and LTVs. The NPRM was published in the Federal Register on December 28, 1967, (32 FR 20865) making the baseline date September 1, 1967, or MY 1968. Since 100 percent of the fleet had this countermeasure by the baseline date, and there are no indications that the countermeasures were upgraded as a result of the standard, there are no incremental costs. The cost of the equipment that was already there will not be considered as voluntarily provided before the NPRM and will not be attributed to the FMVSS.

A study of 37 make-model passenger cars representing pre-standard, post-standard, and trend systems was conducted[46.] The sales-weighted average for the weight and consumer cost of the pre-standard 1968 model year passenger cars was calculated at 3.19 pounds and $23.52 in 2012 dollars. In 1970, the weight and consumer cost in the post-standard model year passenger cars had decreased to 3.06 pounds and $19.17 in 2012 dollars. By 1971, the weight and consumer cost for the trend systems had increased slightly to 3.37 pounds and $20.86 in 2012 dollars. Since all manufacturers met the requirements of FMVSS No. 113 by the 1968 baseline model year, no cost was attributed to the standard. In fact, examination of cars for several years prior to

[46] McVetty, T. N., Cross, A. J., & Parr, L. W. (1982, April). *Cost evaluation for two Federal Motor Vehicle Safety Standards – FMVSS 113 hood latch – passenger cars – FMVSS 219 windshield zone intrusion – passenger cars* (Report No. DOT HS 806 187). Washington, DC: National Highway Traffic Safety Administration, Docket No. 2011-0066-0068.

1968 showed that the safety standard provisions were met in all cases by the domestic industry. It was determined that there were three major reasons for hood latch design changes among the sample:

- the hood lock environment changed due to styling changes or other modifications.
- the trend to inside hood releases, as either an option or standard feature, required a change from a safety catch integral with the latch mechanism to a separate safety catch.
- the designs were revised for cost reduction and simplification.

The Volkswagen Beetle was the only vehicle in the sample whose change in hood latch design came as late as MY 1968. The Volkswagen Beetle would not have complied with the standard in 1966 because no safety catch was provided; it had dual latch systems. However, a design change was made in 1968, and a push button actuated safety catch was added. Because the safety catch was already included in the 1968 model, the baseline year, no cost was attributed to the standard.

FMVSS No. 114, Theft protection and rollaway prevention

FMVSS No. 114 took effect on January 1, 1970, and specifies the requirements for a lock system that prevents the activation of the engine ignition and starting systems, movement of the steering wheel, and movement of the automatic transmission gear selector out of the park position when the key is removed. The purpose of this standard is to:

- reduce thefts and enhance safety by reducing the incidence of crashes resulting from unauthorized operation of a motor vehicle, and
- prevent the rollaway of parked vehicles because of children moving the automatic shift mechanism out of the park position.

This standard applies to passenger cars and to trucks and multipurpose passenger vehicles (almost all LTVs) having a GVWR of 10,000 pounds or less. It does not apply, however, to walk-in van-type vehicles. While this standard would initially have had some cost implications, no cost studies have been performed, and none are planned by this agency.

On March 30, 2010, NHTSA issued a final rule[47] on brake transmission shift interlock that required a vehicle that has a park position to not be allowed to be shifted out of park without the brake pedal being depressed in any starting system key position. The final rule was effective September 1, 2010, for passenger cars, trucks and multi-purpose passenger vehicles (all LTVs) with a GVWR of 10,000 pounds or less. The final rule did not add costs because it was based on a voluntary agreement signed in August 2006 by the Alliance of Automobile Manufacturers and the Association of International Automobile Manufacturers and only resulted in relatively simple mechanical or electrical modifications.

FMVSS No. 115 - [Does not currently exist]

[47] Final Rule issued on March 30, 2010, 79 FR 15621, Docket No. 2010-0043.

FMVSS No. 116, Motor vehicle brake fluids

FMVSS No. 116 took effect on January 1, 1968, and specifies requirements for fluids for use in hydraulic brake systems of motor vehicles, containers for these fluids, and labeling of the container. The purpose of this standard is to reduce failures in the hydraulic braking systems of motor vehicles that may occur because of the manufacture or use of improper or contaminated fluid. Each passenger car, multipurpose passenger vehicle, truck, (all LTVs), bus, trailer, and motorcycle that has a hydraulic brake system shall be equipped with fluid that has been manufactured and packaged in conformity with the requirements of this standard. FMVSS No. 116 would initially have had some cost implications, along with possibly each time it was updated; however, no cost studies have been performed, and none are planned by this agency.

FMVSS No. 117, Retreaded pneumatic tires

FMVSS No. 117 took effect January 1, 1972, and specifies performance, labeling, and certification requirements for retreaded pneumatic passenger car tires. The purpose of this standard is to require retreaded pneumatic passenger car tires to meet safety criteria similar to those for new pneumatic passenger car tires. This standard applies to retreaded pneumatic tires for use on passenger cars manufactured after 1948. Since FMVSS No. 117 does not regulate components of new passenger cars or LTVs, it is outside the scope of this report. No cost studies have been performed, and none are planned by this agency.

FMVSS No. 118, Power-operated window, partition, and roof panel systems

FMVSS No. 118 applies to passenger cars, multipurpose passenger vehicles (MPVs), and trucks with a GVWR of 10,000 pounds or less. This standard specifies requirements for power-operated window, partition, and roof panel systems to minimize the likelihood of death or injury from their accidental operation.

Originally, this standard did not allow the power windows to be operational unless a vehicle's ignition or electrical accessory system was energized via the ignition key. In other words, the opening and closing of the power windows in a parked vehicle without the ignition turned on (potential safety hazard to children or other unsuspecting persons) would not be possible under the standard. In 1975, the standard was amended to add restrictions on the operation of power windows while the passenger doors were ajar.

A final rule was published in the Federal Register on July 23, 1970, (35 FR 11797) for passenger cars and multipurpose passenger vehicles. The NPRM was published in the Federal Register on August 23, 1969, (34 FR 13608) making the baseline date September 1, 1969, or MY 1970.

A final rule was published in the Federal Register on June 24, 1988, (53 FR 23766) extending the requirements to LTVS. The NPRM was published in the Federal Register on October 16, 1987, (52 FR 38488) making the baseline date September 1, 1986, or MY 1987.

Based on information in the Ward's Automotive Yearbook, approximately 14 percent of the baseline 1970 model year domestic passenger cars were equipped with power windows. We don’t know whether the MY 1970 passenger cars met FMVSS No. 118 or not. Thus, we start adding attributable weight and costs with MY 1971 passenger cars, which were required to meet the standard.

The standard’s requirements for power-operated roof panel systems need not be met for vehicles manufactured before September 1, 1993. No cost estimates have been made for power-operated roof panel systems and none are planned.

FMVSS No. 118 was effective for MPVs, which are LTVs, on February 1, 1971, although none of the MPVs had power windows at that time. Based on Ward’s yearbooks, no LTVs had power windows in 1975 and installations of the power windows were appearing in LTVs in 1978. FMVSS No. 118 was extended to light trucks effective July 25, 1988. In this case, we assume power operated windows installed in LTVs in 1978 and later met FMVSS No. 118, since the manufacturers knew what the standards were for passenger cars and MPVs. All power windows in LTVS, other than in MPVs will be considered voluntary through MY 1987 and the voluntary percentage will be held at that MY 1987 baseline level through MY 2012. Attributable costs will be the difference between the installation rates for MY 1988 to MY 2012 minus the voluntary baseline level of MY 1987. These assumptions require us to separate LTVs into MPV’s and light trucks. This was performed on a make/model basis for those vehicles with power windows only, with all pickups and cargo vans considered light trucks and all SUVs and passenger vans considered MPVs.

Power window installations were taken from every third year of the Wards yearbooks and interpolated in between years. Data were taken from the factory installed equipment pages of domestic passenger cars, domestic LTVs, imported passenger cars and imported LTVs and combined into passenger cars and LTVs. LTVs with power windows were divided into MPVs and light trucks and assigned voluntary and attributable weights and costs as described above. This distribution was:

- In MY 1978 the LTVs with power windows were 45 percent MPVs and 55 percent trucks.
- In MY 1981 the LTVs with power windows were 46.9 percent MPVs and 53.1 percent trucks.
- In MY 1984 the LTVs with power windows were 40.4 percent MPVs and 59.6 percent trucks.
- In MY 1987 the LTVs with power windows were 61.3 percent MPVs and 38.7 percent trucks.

While the percentage of the LTV fleet with power windows kept increasing, this distribution between MPVs and trucks with power windows changed rather dramatically because of the models that power windows were introduced in and because MPV sales were rising dramatically in the mid-1980s.

Unfortunately, the Wards yearbooks did not report power windows installations for domestic LTVs for a long period (between MY 1987 and MY 2003). For these years, we took a ratio between domestic LTVs and domestic passenger cars and applied it at an increasing rate to close the gap in knowledge between MY 1987 (when 44.7% of domestic passenger cars and 33.8

percent of domestic LTVs had power windows) to MY 2003 (when 87.6% of domestic passenger cars and 83.0% of domestic LTVs had power windows). Table 118-03 shows the resulting estimated percentage of passenger cars and LTVs with power windows, the average added weight and the average added cost after applying the learning curve.

A cost teardown study was conducted on six make-model passenger cars from two major domestic manufacturers that represented pre-standard, post-standard (MY 1982), and trend systems.[48] The small sample was due to the limited number of vehicles and the model years affected by the standard for these specialty items.

Implementation of the standard involved moving the window system supply wire to a different location and adding a circuit breaker. Since the block fuse mounting was part of the pre-standard make-models, it was decided to base the weight and consumer cost on the addition of the circuit breaker to the post-standard and trend systems. Due to the small sample size, the simple arithmetic average was used instead of the sales-weighted average.

Because NHTSA has not performed teardown analyses of the power window components on LTVs, and because they are similar to the components on passenger cars, we will assume the same costs on LTVs as on passenger cars. The costs don't match in Table 118-02 because of the different percent installation rates for passenger cars and light trucks. Costs generally increase over time, despite the learning curve decreasing costs over time, since the percentage installation rates increase over time.

Table 118-01 shows the average weight and consumer cost of power window components linked to FMVSS No. 118 in passenger cars and LTVs. Table 118-02 shows the weight and consumer cost by model year after applying the learning curve, but before applying the percentage of the fleet with power windows to determine average vehicle costs.

TABLE 118-01
AVERAGE WEIGHT AND CONSUMER COST
OF POWER WINDOW COMPONENTS
LINKED TO FMVSS No. 118
IN PASSENGER CARS AND LTVS

COMPONENT	WEIGHT IN POUNDS	CONSUMER COST ($2012)
Circuit Breaker	0.04	$1.14

[48] Adams, Carlson, Hoffman, & Shideh, DOT HS 806 7741983, Docket No. 2011-0066-0049.

Table 118-02		
FMVSS No. 118 Power Window Weights and Costs After Learning Curve		
Passenger Cars and LTVs		
Model Year	**Added Weight**	**Consumer Cost**
1971	0.04	$1.52
1972	0.04	$1.39
1973	0.04	$1.32
1974	0.04	$1.29
1975	0.04	$1.26
1976	0.04	$1.24
1977	0.04	$1.21
1978	0.04	$1.19
1979	0.04	$1.17
1980	0.04	$1.16
1981	0.04	$1.15
1982	0.04	$1.14
1983	0.04	$1.12
1984	0.04	$1.10
1985	0.04	$1.09
1986	0.04	$1.07
1987	0.04	$1.06
1988	0.04	$1.05
1989	0.04	$1.04
1990	0.04	$1.03
1991	0.04	$1.02
1992	0.04	$1.01
1993	0.04	$1.00
1994	0.04	$0.99
1995	0.04	$0.98
1996	0.04	$0.97
1997	0.04	$0.96
1998	0.04	$0.95
1999	0.04	$0.95
2000	0.04	$0.94
2001	0.04	$0.93
2002	0.04	$0.92
2003	0.04	$0.92
2004	0.04	$0.91

2005	0.04	$0.90	
2006	0.04	$0.90	
2007	0.04	$0.89	
2008	0.04	$0.89	
2009	0.04	$0.89	
2010	0.04	$0.88	
2011	0.04	$0.88	
2012	0.04	$0.87	

Table 118-03
Estimated Percentage of the Fleet With Power Windows
Average Added Weight (lb) and Added Cost (2012$)
For Passenger Cars and LTVs by Model Year

Model Year	Percent Install	Attributable Added Weight	Attributable Consumer Cost	Percent Install	Added Weight		Consumer Cost	
					Voluntary	Attribut.	Voluntary	Attribut.
	PC	PC	PC	LTV	LTV	LTV	LTV	LTV
1971	16.63	0.01	$0.25					
1972	22.56	0.01	$0.31					
1973	21.68	0.01	$0.29					
1974	20.79	0.01	$0.27					
1975	19.91	0.01	$0.25					
1976	21.22	0.01	$0.26					
1977	22.54	0.01	$0.27					
1978	23.85	0.01	$0.28	2.09	0.00	0.00	$0.01	$0.01
1979	23.69	0.01	$0.28	3.48	0.00	0.00	$0.02	$0.02
1980	23.54	0.01	$0.27	4.88	0.00	0.00	$0.03	$0.03
1981	23.39	0.01	$0.27	6.28	0.00	0.00	$0.04	$0.03
1982	29.01	0.01	$0.33	10.51	0.00	0.00	$0.07	$0.05
1983	34.66	0.01	$0.39	14.75	0.00	0.00	$0.10	$0.07
1984	40.28	0.02	$0.45	18.99	0.00	0.00	$0.13	$0.08
1985	41.01	0.02	$0.45	21.79	0.00	0.00	$0.13	$0.11
1986	41.74	0.02	$0.45	24.61	0.00	0.01	$0.13	$0.14
1987	42.47	0.02	$0.45	27.41	0.00	0.01	$0.12	$0.18
1988	45.57	0.02	$0.48	31.30	0.01	0.00	$0.29	$0.04
1989	48.67	0.02	$0.50	35.19	0.01	0.00	$0.28	$0.08
1990	51.77	0.02	$0.53	39.08	0.01	0.00	$0.28	$0.12
1991	54.86	0.02	$0.56	42.97	0.01	0.01	$0.28	$0.16
1992	59.16	0.02	$0.60	47.16	0.01	0.01	$0.28	$0.20
1993	63.46	0.03	$0.63	51.37	0.01	0.01	$0.27	$0.24

1994	67.76	0.03	$0.67	55.56	0.01	0.01	$0.27	$0.28
1995	70.59	0.03	$0.69	58.65	0.01	0.01	$0.27	$0.31
1996	73.44	0.03	$0.71	61.74	0.01	0.01	$0.27	$0.33
1997	76.27	0.03	$0.73	64.82	0.01	0.01	$0.26	$0.36
1998	78.33	0.03	$0.75	68.28	0.01	0.02	$0.26	$0.39
1999	80.40	0.03	$0.76	71.75	0.01	0.02	$0.26	$0.42
2000	82.46	0.03	$0.77	75.21	0.01	0.02	$0.26	$0.45
2001	84.21	0.03	$0.78	78.39	0.01	0.02	$0.25	$0.47
2002	85.95	0.03	$0.79	81.58	0.01	0.02	$0.25	$0.50
2003	87.70	0.04	$0.80	84.76	0.01	0.02	$0.25	$0.53
2004	93.24	0.04	$0.85	87.37	0.01	0.02	$0.25	$0.54
2005	92.13	0.04	$0.83	83.79	0.01	0.02	$0.25	$0.51
2006	93.97	0.04	$0.84	87.02	0.01	0.02	$0.25	$0.53
2007	95.81	0.04	$0.85	90.24	0.01	0.03	$0.24	$0.56
2008	95.70	0.04	$0.85	90.91	0.01	0.03	$0.24	$0.56
2009	95.60	0.04	$0.85	91.58	0.01	0.03	$0.24	$0.57
2010	96.39	0.04	$0.85	91.77	0.01	0.03	$0.24	$0.57
2011	97.18	0.04	$0.85	91.96	0.01	0.03	$0.24	$0.57
2012	97.97	0.04	$0.86	92.14	0.01	0.03	$0.24	$0.57

FMVSS No. 119, New pneumatic tires for motor vehicles with a GVWR of more than 4,536 kilograms (10,000 pounds) and motorcycles

FMVSS No. 119 took effect on March 1, 1975, and establishes performance and marking requirements for tires for use on vehicles other than passenger cars. The purpose of this standard is to:

- provide safe operational levels for tires used on motor vehicles other than passenger cars, and
- place sufficient information on the tires to permit their proper selection and use.

This standard applies to new pneumatic tires designed for highway use on multipurpose passenger vehicles, trucks, buses, trailers, and motorcycles manufactured after 1948.
Since this standard does not regulate components of new passenger cars or LTVs, it is outside the scope of this report. No cost studies have been performed, and none are planned by this agency.

FMVSS No. 120, Tire selection and rims and motor home/recreation vehicle trailer load carrying capacity information for motor vehicles with a GVWR of more than 4,536 kilograms (10,000 pounds)

FMVSS No. 120 took effect on August 1, 1976, and specifies tire and rim selection requirements and rim marking requirements. The purpose of this standard is to provide safe operational performance by ensuring that vehicles to which it applies are equipped with tires of adequate size and load rating and with rims of appropriate size and type designation. This standard applies to tires, rims, and non-pneumatic spare tire assemblies on multipurpose passenger vehicles, trucks, buses, trailers, and motorcycles. Since this standard does not regulate components of new passenger cars or LTVs, it is outside the scope of this report. No cost studies have been performed, and none are planned by this agency.

FMVSS No. 121, Air brake systems

FMVSS No. 121 originally went into effect for trucks, buses, and trailers on January 1, 1975, specifying performance standards and tests for air brake systems. In 1996 NHTSA issued final rules amending FMVSS No. 121 (and also FMVSS No. 105) to require ABS and a malfunction indicator lamp on all new vehicles with GVWR greater than 10,000 pounds. The ABS requirement went into effect for air-brake truck tractors manufactured on or after March 1, 1997, for air-brake trailers and single-unit trucks manufactured on or after March 1, 1998, and for hydraulic-brake trucks manufactured on or after March 1, 1999. The requirement for the malfunction indicator lamp on the vehicle went into effect simultaneously with the ABS requirement; furthermore, starting March 1, 2001, the truck tractor was required to display, within the cab, a malfunction indicator lamp for each trailer attached to it.[49]

The purpose of this standard is to insure safe braking performance under normal and emergency conditions. It is important to note that even before the standard went into effect, the manufacturers of truck-tractors, trailers, and other heavy vehicles were offering ABS in different configurations as optional equipment.

Since FMVSS No. 121 does not regulate components of new passenger cars or LTVs, it is outside the scope of this report. However, a study was conducted in 2000 and Table 121-1 shows the arithmetic average weight and consumer cost of two air-braked truck-tractor ABS, two air-braked trailer ABS, and one tractor-trailer connection.[50] The connections between the tractors and the trailers are standardized by industry practice and by applicable standards and guidelines, which allows for interchangeability between various trailers and the towing tractors. (Of course, none of the costs of FMVSS No. 121 apply to passenger cars or LTVs because they are equipped with hydraulic brakes, not air brakes).

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[49] 49 CFR, Part 571.121; *Federal Register* 61 (May 31, 1996): 27290.

[50] Khadilkar, A. V., Fladmark, G. L., & Khadilkar, J. (2002, November). *Teardown cost estimates of automotive equipment manufactured to comply with Motor Vehicle Standards, FMVSS 121 (air brake systems) and FMVSS 105 (hydraulic brake systems), antilock brake features*. (Report No. DOT HS 809 808). Washington, DC: National Highway Traffic Safety Administration, Docket No. 2011-0066-0014.

TABLE 121-1 AVERAGE WEIGHT AND CONSUMER COST OF ABS IN AIR-BRAKED TRUCK-TRACTORS AND TRAILERS		
ABS	**WEIGHT IN POUNDS**	**CONSUMER COST ($2012)**
Truck-Tractor		
2000 Navistar International Class 7 Bendix ABS	31.71	$756.07
2000 Freightliner Class 8 Meritor/Wabco ABS	18.76	$612.76
Trailer		
2000 Great Dane Meritor/Wabco ABS	31.74	$610.89
2000 Utility International Haldex ABS	33.19	$488.94
Tractor-Trailer Connection		
	9.54	$119.49

FMVSS No. 122, Motorcycle brake systems

FMVSS No. 122 took effect on January 1, 1974, 1974, and specifies performance requirements for motorcycle brake systems. The purpose of the standard is to insure safe motorcycle braking performance under normal and emergency conditions. This standard only applies to motorcycles. Since this standard does not regulate components of new passenger cars or LTVs, it is outside the scope of this report. No cost studies have been performed, and none are planned by this agency for basic motorcycle brake systems costs. However, a cost study has been performed on motorcycle antilock brake systems.[51] Motorcycle ABS systems are not required.

TABLE 122-1 AVERAGE WEIGHT AND CONSUMER COST OF ABS IN MOTORCYCLES		
ABS	**WEIGHT IN POUNDS**	**CONSUMER COST ($2012)**
2011 Harley Davidson	6.35	$315.23
2011 Suzuki SV 650	6.24	$304.80

FMVSS No. 123, Motorcycle controls and displays

FMVSS No. 123 took effect on September 1, 1974, and specifies requirements for the location, operation, identification, and illumination of motorcycle controls and displays and requirements for motorcycle stands and footrests. The purpose of this standard is to minimize accidents caused by operator error in responding to the motoring environment by standardizing certain motorcycle controls and displays. This standard applies to motorcycles equipped with handlebars, except for

[51] Ludtke & Associates. (2011). *Cost and weight teardown for two ABS motorcycle braking systems, Harley Davidson (domestic) and Suzuki SV 650 (foreign).* . Washington, DC: National Highway Traffic Safety Administration. In Docket No. NHTSA-2011-0066-0035.

motorcycles that are designed and sold exclusively for use by law enforcement agencies. Since this standard does not regulate components of new passenger cars or LTVs, it is outside the scope of this report. No cost studies have been performed, and none are planned by this agency.

FMVSS No. 124, Accelerator control systems

FMVSS No. 124 took effect on September 1, 1973, and establishes requirements for the return of a vehicle's throttle to the idle position when the driver removes his or her foot from the accelerator control or in the event of a severance or disconnection in the accelerator control system. The purpose of this standard is to reduce deaths and injuries resulting from engine over-speed when the accelerator fails to return to the up position. This standard applies to passenger cars, multipurpose passenger vehicles, trucks, (all LTVs), and buses.

The final rule was published in the Federal Register on April 8, 1972, (37 FR 7097), for passenger cars and LTVs. The NPRM was published in the Federal Register on September 30, 1970, (35 FR 15241), making the baseline date September 1, 1970, for MY 1971. NHTSA knows that all MY 1973 passenger cars and LTVs met the standard by the effective date, but has no data that would indicate that any pre-standard systems complied. None of the nine pre-standard make-models in the cost teardown that were MY 1971 or MY 1972 complied. Thus, 100 percent of the passenger cars and LTVs are considered attributable to the standard starting in MY 1973 and no voluntary compliance is assumed.

Accelerator control systems were difficult to analyze because changes were being made to the carburetor systems to meet EPA fuel conservation and emissions systems standards at the same time FMVSS No. 124 went into effect. However, the standard was met by having two energy sources, an inner and outer accelerator return spring, which were capable of returning the throttle to the idle position.

A study was conducted on six make-model passenger cars from four major manufacturers, two LTVs and one bus that represented pre-standard, post-standard, and trend systems.[52] Analysis of each system identified an increase in the weight and consumer cost from the pre-standard make-models to the post-standard make-models. While a comparison of the post-standard and trend systems indicated that four out of the six passenger car make-models decreased in cost, three out of those four make-models were from the same manufacturer, General Motors. The lack of evidence to support a significant trend, therefore, justifies the use of the simple arithmetic average instead of the sales-weighted average for the weight and consumer cost. The arithmetic average for the weight and consumer cost of the pre-standard make-models was calculated at 0.02 pounds and $0.56 in 2012 dollars; the post-standard (averaging MY 1982 vehicles) was calculated at 0.04 pounds and $1.13; the trend systems were calculated at 0.03 pounds and $0.91.

Based on the teardown analysis, where the accelerator control systems on LTVs were similar to the systems on passenger cars, we averaged the costs together for passenger cars and LTVs.

Table 124-1 shows the actual weight and cost increments of accelerator control systems for FMVSS No. 124 in passenger cars and LTVs.

[52] Adams, Carlson, Hoffman, & Shideh, DOT HS 806 774, 1983, Docket No. 2011-0066-0049.

TABLE 124-1 AVERAGE WEIGHT AND CONSUMER COST OF ACCELERATOR CONTROL SYSTEMS FMVSS No. 124 IN PASSENGER CARS AND LTVS		
CATEGORY	**WEIGHT IN POUNDS**	**CONSUMER COST ($2012)**
Pre-Standard	0.02	$0.56
Post-Standard	0.04	$1.13
DIFFERENCE	0.02	$0.57

Table 124-2 shows the weight and cost attributable to passenger cars and LTVs for accelerator control systems after applying the learning curve to the estimates of the difference in costs between pre-standard and post-standard systems. The learning curve, and $0.57 cost, is centered on MY 1982 because that was the median model year in the sample of vehicles studied. After applying the learning curve, costs are higher before MY 1982 and lower after MY 1982.

Table 124-2 Average Weight (lb) and Cost (2012$) of Accelerator Controls Attributable to FMVSS No. 124 Passenger Cars and LTVs				
Model Year	**PC Weight**	**PC Cost**	**LTV Weight**	**LTV Cost**
1973	0.02	$0.71	0.02	$0.71
1974	0.02	$0.67	0.02	$0.67
1975	0.02	$0.65	0.02	$0.65
1976	0.02	$0.63	0.02	$0.63
1977	0.02	$0.61	0.02	$0.61
1978	0.02	$0.60	0.02	$0.60
1979	0.02	$0.59	0.02	$0.59
1980	0.02	$0.58	0.02	$0.58
1981	0.02	$0.57	0.02	$0.57
1982	0.02	$0.57	0.02	$0.57
1983	0.02	$0.56	0.02	$0.56
1984	0.02	$0.56	0.02	$0.56
1985	0.02	$0.55	0.02	$0.55
1986	0.02	$0.55	0.02	$0.55
1987	0.02	$0.54	0.02	$0.54
1988	0.02	$0.54	0.02	$0.54
1989	0.02	$0.53	0.02	$0.53
1990	0.02	$0.53	0.02	$0.53
1991	0.02	$0.53	0.02	$0.53
1992	0.02	$0.52	0.02	$0.52

1993	0.02	$0.52	0.02	$0.52
1994	0.02	$0.52	0.02	$0.52
1995	0.02	$0.52	0.02	$0.52
1996	0.02	$0.51	0.02	$0.51
1997	0.02	$0.51	0.02	$0.51
1998	0.02	$0.51	0.02	$0.51
1999	0.02	$0.51	0.02	$0.51
2000	0.02	$0.50	0.02	$0.50
2001	0.02	$0.50	0.02	$0.50
2002	0.02	$0.50	0.02	$0.50
2003	0.02	$0.50	0.02	$0.50
2004	0.02	$0.50	0.02	$0.50
2005	0.02	$0.49	0.02	$0.49
2006	0.02	$0.49	0.02	$0.49
2007	0.02	$0.49	0.02	$0.49
2008	0.02	$0.49	0.02	$0.49
2009	0.02	$0.49	0.02	$0.49
2010	0.02	$0.49	0.02	$0.49
2011	0.02	$0.49	0.02	$0.49
2012	0.02	$0.48	0.02	$0.48

FMVSS No. 125, Warning devices

FMVSS No. 125 took effect on January 1, 1974, 1974, and establishes shape, size, and performance requirements for reusable day and night warning devices that can be erected on or near the roadway to warn approaching motorists of the presence of a stopped vehicle. The purpose of this standard is to reduce deaths and injuries due to rear-end collisions between moving traffic and disabled vehicles. This standard applies to devices that do not have self-contained energy sources and are designed to be carried in buses and trucks that have a GVWR greater than 10,000 pounds. Since this standard does not regulate components of new passenger cars or LTVs, it is outside the scope of this report. No cost studies have been performed, and none are planned by this agency.

FMVSS No. 126, Electronic stability control systems

On April 6, 2007, (72 FR 17236), NHTSA published in the Federal Register a final rule on FMVSS No. 126 to require ESC on passenger cars, multipurpose passenger vehicles, trucks, (all LTVs), and buses with a GVWR of 10,000 pounds or less with a phase-in comprising 55 percent of MY 2009 sales, 75 percent of MY 2010, 95 percent of MY 2011, and all new vehicles by MY 2012. ESC was first offered on selected MY 1997 passenger cars.

On September 18, 2006, NHTSA proposed FMVSS No. 126 (71 FR 54712). Thus, the baseline date is September 1, 2006, or MY 2007. Since 100 percent of the fleet did not have ESC before the baseline date, ESC costs will be considered voluntary through MY 2007 and the voluntary percentage will be held at that MY 2007 baseline level through MY 2012. Attributable costs will be the difference between the installation rates for MY 2008 to MY 2012 minus the voluntary baseline level of MY 2007.

ESC systems detect when a vehicle is about to lose traction and automatically apply the brakes to individual wheels and/or reduce engine torque to help the driver stay on course. They are a highly effective crash avoidance technology. ESC systems detect and automatically assist drivers in oversteer and understeer situations that lead to loss of control and occur especially in unfavorable conditions such as rain, snow, sleet, or ice. Oversteer is when the vehicle turns more than the driver wants and is called spinning out. Understeer is when the vehicle turns less than the driver intends and is called plowing out. Sensors monitor the speed of each wheel, the steering wheel angle, and the yaw rate and estimate the slip of the vehicle in order to brake individual wheels and reduce engine torque so that the driver can maintain directional control. The yaw rate is the rate of change of the vehicle’s heading. The system compares the measured yaw rate of the vehicle to the driver’s intended rate of change of heading (as evidenced by the steering wheel angle) consistent with the speed and lateral acceleration of the vehicle. For example, a yaw rate measurement greater than that consistent with the vehicle’s heading angle and corresponding steering wheel angle indicates oversteer. ESC rapidly and automatically intervenes to correct the vehicle heading by applying the brakes to individual wheels and possibly reducing engine torque to help the driver stay on the road. If the vehicle was experiencing the onset of oversteer in a left curve, ESC would momentarily apply the brake to the right front wheel to counteract the excessive yaw rate and stabilize the vehicle. During an understeer scenario, if a driver was attempting to drive around a left curve, the ESC system momentarily applies the left rear brake, creating a clockwise rotational force, to turn the heading of the vehicle back to the correct path. It will also reduce engine power to gently slow the vehicle and, if necessary, apply additional brakes.

All current vehicles with ESC are also equipped with ABS and traction control systems; the ESC to a large extent builds on ABS technology and shares ABS components. All of the ABS costs were accounted for in FMVSS No. 105. ESC (without ABS costs added in) is assumed to be voluntarily provided through the baseline year of MY 2007 and the voluntary percentage will be held at that MY 2007 baseline level through MY 2012. Attributable costs for ESC (without ABS costs added in) will be the difference between the installation rates for MY 2008 to MY 2012 minus the voluntary baseline level of MY 2007. The same accounting assumptions are made for weight.

Mercedes-Benz first offered ESC in 1997 as standard equipment on top-of-the-line subseries or as an option on other subseries of its S and SL luxury cars. The next year, BMW was the first with ESC standard on an entire make-model, its 700-series. By 2000, it was standard on most BMW and Mercedes cars, Cadillac Seville, and a few other GM luxury models, Lexus LS and GS, and Acura RL. Among SUVs, ESC was standard on Mercedes ML in 1999, on Lexus LX in 2000, followed by Toyota 4Runner and Land Cruiser and Lexus RX the next year.

Although traction control systems which automatically reduce output torque to certain drive wheels in certain driving conditions may use the same brake components as the ESC system, traction control systems are not required by FMVSS No. 126 and are not considered by NHTSA to be a safety system, but more of a convenience feature. Thus, traction control systems are not included in this report.

Teardown cost estimates[53] were provided on ESC, ABS, and traction control for 11 vehicles, 9 of which were MY 2005 vehicles, one from MY 2004 and one from MY 2006. The estimates were summarized in the Final Regulatory Impact Analysis.[54] Based on the teardowns of a variety of vehicles of Asian, European, and domestic passenger cars and LTVs, it was assumed that the same cost would apply for both passenger cars and LTVs. The estimates were incremental to the hydraulic brake systems already on the vehicles. Tables 105-8a, 105-8b, 105-9 and 105-14 provide the weight and cost estimates for ABS. Table 126-1 shows the individual components for ESC.

Table 126-1 **Average Weight (lb) and Cost (2012$)** **Electronic Stability Control Components** **Passenger Cars and LTVs**		
	Weight	**Cost**
Yaw Rate/Lateral Acceleration Sensors	0.78	$68.76
Steering Wheel Sensor	0.35	$31.45
Integrated Control Unit (over ABS)	0.61	$20.07
Wires/Telltale Light	0.08	$6.30
Total	1.82	$126.57

Table 126-2 provides the estimated percent of the fleet with ESC and the cost per vehicle after applying the learning curve. The $126.57 cost for ESC was for a MY 2005 vehicle. After applying the learning curve the cost per vehicle is higher in the years prior to MY 2005 and lower in years after MY 2005.

[53] Ludtke & Associates. (n.a.) *Cost and Weight Analysis of the Combined System of Electronic Stability Control (ESC), Antilock Braking System (ABS), and Traction Control System (TCS)*, Volumes 1 and II, Docket No. 2011-0066-0005 and 2011-0066-0006

[54] NHTSA. (2007, March). *Final Regulatory Impact Analysis, FMVSS No 126, Electronic Stability Control Systems*, Docket No. 2007-27662-0002.

Table 126-2			
Electronic Stability Control Systems			
Percentage of Fleet Installed and Learned Costs			
Passenger Cars and LTVs			
Model Year	**PC Percent**	**LTV Percent**	**Learned Cost per Vehicle**
1998	0.26	0.00	$238.44
1999	1.91	0.60	$185.13
2000	4.98	0.67	$164.45
2001	7.20	3.08	$151.47
2002	8.01	4.89	$143.55
2003	11.77	8.39	$136.50
2004	12.52	11.92	$131.06
2005	12.50	16.82	$126.57
2006	19.75	30.89	$121.52
2007	20.17	49.44	$116.99
2008	30.04	62.01	$113.65
2009	36.05	81.55	$111.10
2010	74.89	88.16	$108.04
2011	88.72	94.44	$105.20
2012	100	100	$102.54

Tables 126-3 and 126-4 show the average voluntary and attributable weights and costs per vehicle for passenger cars and LTVs, respectively.

Table 126-3						
FMVSS No. 126 Electronic Stability Control for Passenger Cars						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1997	0.0	0.0	0.0	$0.00	$0.00	$0.00
1998	0.0	0.0	0.0	$0.62	$0.00	$0.62
1999	0.0	0.0	0.0	$3.54	$0.00	$3.54
2000	0.1	0.0	0.1	$8.19	$0.00	$8.19
2001	0.1	0.0	0.1	$10.91	$0.00	$10.91
2002	0.1	0.0	0.1	$11.50	$0.00	$11.50
2003	0.2	0.0	0.2	$16.07	$0.00	$16.07
2004	0.2	0.0	0.2	$16.41	$0.00	$16.41
2005	0.2	0.0	0.2	$15.82	$0.00	$15.82
2006	0.4	0.0	0.4	$24.00	$0.00	$24.00
2007	0.4	0.0	0.4	$23.60	$0.00	$23.60
2008	0.4	0.2	0.5	$22.92	$11.22	$34.14
2009	0.4	0.3	0.7	$22.41	$17.64	$40.05
2010	0.4	1.0	1.4	$21.79	$59.12	$80.91
2011	0.4	1.2	1.6	$21.22	$72.12	$93.34
2012	0.4	1.5	1.8	$20.68	$81.86	$102.54

Table 126-4						
FMVSS No. 126 Electronic Stability Control for LTVs						
Model Year	Weight (lb)			Consumer Cost (2012$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1997	0.0	0.0	0.0	$0.00	$0.00	$0.00
1998	0.0	0.0	0.0	$0.00	$0.00	$0.00
1999	0.0	0.0	0.0	$1.11	$0.00	$1.11
2000	0.0	0.0	0.0	$1.10	$0.00	$1.10
2001	0.1	0.0	0.1	$4.67	$0.00	$4.67
2002	0.1	0.0	0.1	$7.02	$0.00	$7.02
2003	0.2	0.0	0.2	$11.45	$0.00	$11.45
2004	0.2	0.0	0.2	$15.62	$0.00	$15.62
2005	0.3	0.0	0.3	$21.29	$0.00	$21.29
2006	0.6	0.0	0.6	$37.54	$0.00	$37.54
2007	0.9	0.0	0.9	$57.84	$0.00	$57.84
2008	0.9	0.2	1.1	$56.19	$14.29	$70.47
2009	0.9	0.6	1.5	$54.93	$35.67	$90.60
2010	0.9	0.7	1.6	$53.42	$41.83	$95.25
2011	0.9	0.8	1.7	$52.01	$47.34	$99.35
2012	0.9	0.9	1.8	$50.70	$51.84	$102.54

FMVSS No. 127 - [Does not currently exist]

FMVSS No. 128 - [Does not currently exist]

FMVSS No. 129, New non-pneumatic tires for passenger cars

FMVSS No. 129 took effect on August 20, 1990, and specifies tire dimensions and laboratory test requirements for lateral strength, endurance, and high-speed performance; defines the tire load rating; and defines labeling requirements for non-pneumatic spare tires. This standard applies to new temporary spare non-pneumatic tires for use on passenger cars. Since this standard does not require new passenger cars or LTVs to have the optional non-pneumatic tires, no cost studies have been performed, and none are planned by this agency.

FMVSS No. 130 - [Does not currently exist]

FMVSS No. 131, School bus pedestrian safety devices

FMVSS No. 131 took effect on May 3, 1991, and establishes requirements for devices (stop signal arms) that can be installed on school buses to improve the safety of pedestrians near stopped school buses. The purpose of this standard is to reduce deaths and injuries by minimizing the likelihood of vehicles passing a stopped school bus and striking pedestrians near the bus. Since this standard does not regulate components of new passenger cars or LTVs, it is outside the scope of this report. No cost studies have been performed, and none are planned by this agency.

FMVSS No. 132 - [Does not currently exist]

FMVSS No. 133 - [Does not currently exist]

FMVSS No. 134 - [Does not currently exist]

FMVSS No. 135, Light vehicle brake systems

This standard specifies requirements for vehicles equipped with hydraulic and electric service brakes and parking brake systems. The purpose of the standard is to ensure safe braking performance under normal conditions and emergency conditions. This standard applies to passenger cars manufactured on or after September 1, 2000, and to multipurpose passenger vehicles, trucks, and buses with a GVWR of 7,716 pounds or less, manufactured on or after September 1, 2002. In addition, at the option of the manufacturer, passenger cars manufactured before September 1, 2000, and multipurpose passenger vehicles, trucks, and buses with a GVWR of 7,716 pounds or less manufactured before September 1, 2002, may meet the requirements of this standard instead of FMVSS No. 105. FMVSS No. 135 is an update to FMVSS No. 105, including harmonizing some of the test requirements with Europe. It is not believed to have significantly increased the weight or cost of brake systems. However, no cost studies have been performed.

FMVSS No. 136 - [Does not currently exist]

FMVSS No. 137 - [Does not currently exist]

FMVSS No. 138, Tire pressure monitoring systems

Section 13 of the TREAD Act of 2000 directed NHTSA to upgrade tire performance, including a requirement for systems that warn the driver when a tire is significantly underinflated – a situation that poses a safety risk, increasing the chance of skidding, hydroplaning, longer stopping distances, and crashes due to flat tires and blowouts. On April 8, 2005, (49 FR 18136), NHTSA published in the Federal Register a new safety standard, FMVSS No. 138, Tire pressure monitoring systems, requiring TPMS in all new cars and LTVs with GVWR of 10,000 pounds or less built after September 1, 2007, (MY 2008). The two-year phase-in period required TPMS on 20 percent of MY 2006 vehicles and 70 percent of MY 2007. A vehicle's TPMS must warn the driver when one or more of the vehicle's tires is severely underinflated – i.e., has fallen to 25 percent or more below the nominal pressure to which the TPMS has been calibrated. Ordinarily, the TPMS should be calibrated to the placard pressure recommended by the manufacturer for that vehicle, which is usually on a label on the inside of the driver's door frame. The display, a warning light on the instrument panel, must activate within 20 minutes of underinflated travel at speeds of 50 to 100 km/h and must remain illuminated until the underinflation is remedied. The system must also have a malfunction lamp in addition to a low-pressure warning lamp that alerts the driver if the vehicle's TPMS is not functioning properly.

This standard applies to passenger cars, multipurpose passenger vehicles, trucks, (all LTVs), and buses with a GVWR of 10,000 pounds or less, except those vehicles with dual wheels on an axle.

The NPRM was published in the Federal Register on July 26, 2001, (66 FR 38984) making the baseline date September 1, 2000, or MY 2001. Since 100 percent of the fleet did not have TPMS by the baseline date, TPMS costs will all be considered voluntary through MY 2001 and the voluntary percentage will be held at that MY 2001 baseline level through MY 2012. Attributable costs will be the difference between the installation rates for MY 2002 to MY 2012 minus the voluntary baseline level of MY 2001.

There are two distinct types of TPMS that have been installed on production vehicles at various times since 2000 - an indirect system and the direct system. In vehicles equipped with ABS, indirect TPMS relies on the ABS system, which has sensors that continually monitor the speed of the four wheels. The operating principle is that if a single wheel has a faster rotational speed than other wheels, then its radius or rolling circumference must be smaller and therefore the tire may be underinflated, triggering the warning light if the difference in speeds is large enough. Because the indirect systems of the early 2000s could only detect relative wheel speeds, they could not detect when two to four tires lost pressure at about the same rate and were all underinflated. FMVSS No. 138 required the TPMS to be capable of detecting underinflation in one or more of the tires, up to a total of four tires. As a result most manufacturers began exclusively installing direct systems after publication of the final rule. While a small percentage of sales in the early 2000s had indirect TPMS, these are not considered as voluntarily compliance with the standard, since these indirect TPMS systems did not meet the requirements of the final rule. We attempted to estimate the percentage of the fleet with indirect TPMS from MY 2000 to MY 2006. This is an inexact science since TPMS was optional on several models and we did not know the percentage of those models sold with TPMS. Table 138-1 shows these estimates for passenger cars and LTVs. The percentage of new vehicles sold with TPMS rose from year to year until MY 2004, when several models were changed from providing TPMS as standard equipment to providing TPMS as optional equipment. By MY 2006, sales of direct TPMS systems picked up dramatically for passenger cars and dropped dramatically for indirect TPMS systems.

Table 138-1		
Estimated Percentage of New Vehicle Sales		
With Indirect TPMS		
Passenger Cars and LTVs		
Model Year	**Passenger Cars**	**LTVs**
2000	4.52	1.00
2001	7.23	4.47
2002	8.74	4.60
2003	9.32	2.78
2004	7.65	2.55
2005	12.94	4.63
2006	0.42	0.84

In theory there would be some reduction in cost in removing indirect TPMS systems from vehicles. NHTSA does not have a cost teardown estimate for indirect TPMS systems. Since they were based on the ABS system, they most likely would involve developing the software and computing power to determine when to give a warning along with the warning light itself. Since the software development was already spent and both the software development and computing power would have to be redeveloped for the direct system, the only tangible savings might be in the warning light. We examined the basic warning lights in the direct TPMS cost teardown discussed later and found the average cost to be $0.36 in 2012 dollars. When applied to the baseline percentage of the fleet of MY 2001 TPMS (7.23 percent of passenger cars and 4.47 percent of LTVs), the savings would amount to $0.03 for passenger cars and $0.02 for LTVs. Since we don't have a real cost estimate and we believe it would be rather small, NHTSA is not assuming a baseline cost for indirect TPMS that would offset some of the cost of direct TPMS.

In 2009 the Audi A6 was the first indirect system to certify compliance with FMVSS 138. In 2010, 2011, and 2012 several Audi and Volkswagen models came equipped with indirect systems. These indirect systems integrate data from the ABS and electronic stability control systems along with information from other evolving technology sensors into a diagnostic model and compare that data to historical data. NHTSA is, as of January 2016, having a contractor perform a cost teardown estimate for these newer indirect systems. These systems have many fewer parts dedicated to just TPMS and will be much less expensive.

Direct TPMS uses a battery-powered pressure sensor and a radio transmitter inside each tire that periodically broadcasts the tire pressure to a central processing unit in the vehicle. The sensors are most often located on the interior end of a tire's valve stems. Some direct systems, in addition to the warning light, display the actual pressure of each tire on the dash, allowing the driver to diagnose overinflation as well as underinflation. The batteries have a finite life, variously estimated to range from 6 to 12 years or from 50,000 to 100,000 miles. When a battery expires, the entire wheel sensor must be replaced or the TPMS system won't work.

The direct monitoring systems include the following components.

1. An air pressure sensor mounted inside each tire's inner air chamber. One vehicle had the monitor attached to a strap that encircled the wheel at a location inside the tire, but most contained the monitor within the tire air injection valve system.
2. A transmitter for each tire that sends the pressure read out to a receiver mounted on the car body.
3. A receiver mounted on the car body.
4. A computer component that converts the air pressure data into a readout format for display on the vehicle instrument panel.
5. A method of transmitting the data to a display unit on the instrument panel.
6. A display on the instrument panel. This display varies from a light that tells the driver that tire pressure is low, to a display that tells the driver the tire pressure in each identified tire at any time, accompanied by a light that indicates that the tire pressure is low.

The cost of direct TPMS was examined in a cost teardown study.[55] Six direct MY 2008 TPMS systems were examined (3 from passenger cars and 3 from LTVs, including 2 Japanese, 2 European, and 2 domestic models) from a variety of suppliers around the world, to provide a representation from the major world-wide auto manufacturing areas. There was no pattern indicating the passenger car TPMS systems were more or less expensive than LTV TPMS systems or that Japanese systems were any more or less expensive than European or domestic systems (see Table 138-2). In the small sample we examined, the difference lies mainly in the type of display on the instrument panel. Thus, we decided to use a simple average of all of the TPMS weights and costs and use them for both passenger cars and LTVs.

Table 138-2		
Average Weight and Cost of TPMS		
Passenger Cars and LTVs		
	Weight	**Cost**
	(Pounds)	**(2012$)**
Japanese	0.66	$107.88
European	0.84	$218.24
Domestic	2.37	$194.58
LTVs		
Japanese	4.05	$253.03
European	1.02	$173.40
Domestic	1.11	$146.31
Average	1.67	$182.24

[55] Ludtke & Associates, *Cost, Weight Analysis of Tire Pressure Monitoring Systems*, Docket No. 2011-0066-0003.

The percentage of the fleet with direct TPMS was estimated based on determining which make-models were equipped with direct TPMS and using information reported by manufacturers to NHTSA's compliance office for MY 2004 to 2008 (see Table 138-3). Some manufacturers relied heavily on carry-forward credits to meet the phase-in requirements as all complying vehicles manufactured after August 8, 2005, could be counted as carry-forward credits. As shown in Table 138-3, the manufacturers would not have met the 70-percent phase-in requirement for MY 2007 without carry-forward credits. There were some starts and stops to the FMVSS No. 138 rulemaking process, but we will use the baseline of MY 2001 for determining voluntary and attributable costs. Table 138-3 also shows the consumer costs after applying the learning curve by model year.

Tables 138-4 and 138-5 provide the average weight and consumer cost of TPMS for passenger cars and LTVs on a model year basis.

Table 138-3
Percentage of New Vehicle Fleet With Direct TPMS
Or Compliant Indirect TPMS Plus Learned Costs
Passenger Cars and LTVs

Model Year	Passenger Cars	LTVs	Learned Costs
2001	2.11	0.42	$309.00
2002	2.18	1.48	$281.52
2003	2.59	1.00	$268.82
2004	7.70	21.38	$231.25
2005	7.77	30.00	$215.08
2006	21.38	30.82	$204.18
2007	44.68	61.32	$192.28
2008	100	100	$182.24
2009	100	100	$177.08
2010	100	100	$172.75
2011	100	100	$169.01
2012	100	100	$165.62

Table 138-4						
FMVSS No. 138 TPMS for Passenger Cars						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
2000	0.00	0.00	0.00	$0.00	$0.00	$0.00
2001	0.04	0.00	0.04	$6.51	$0.00	$6.51
2002	0.04	0.00	0.04	$5.93	$0.20	$6.13
2003	0.04	0.01	0.04	$5.66	$1.29	$6.96
2004	0.04	0.09	0.13	$4.87	$12.95	$17.82
2005	0.04	0.09	0.13	$4.53	$12.17	$16.70
2006	0.04	0.32	0.36	$4.30	$39.34	$43.64
2007	0.04	0.71	0.75	$4.05	$81.87	$85.92
2008	0.04	1.63	1.67	$3.84	$178.40	$182.24
2009	0.04	1.63	1.67	$3.73	$173.35	$177.08
2010	0.04	1.63	1.67	$3.64	$169.11	$172.75
2011	0.04	1.63	1.67	$3.56	$165.45	$169.01
2012	0.04	1.63	1.67	$3.49	$162.13	$165.62

Table 138-5						
FMVSS No. 138 TPMS for LTVs						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
2000	0.00	0.00	0.00	$0.00	$0.00	$0.00
2001	0.01	0.00	0.01	$1.29	$0.00	$1.29
2002	0.01	0.02	0.02	$1.17	$2.99	$4.16
2003	0.01	0.01	0.02	$1.12	$1.57	$2.69
2004	0.01	0.35	0.36	$0.96	$48.47	$49.43
2005	0.01	0.49	0.50	$0.90	$63.62	$64.52
2006	0.01	0.51	0.51	$0.85	$62.07	$62.93
2007	0.01	1.02	1.02	$0.80	$117.12	$117.92
2008	0.01	1.66	1.67	$0.76	$181.48	$182.24
2009	0.01	1.66	1.67	$0.74	$176.34	$177.08
2010	0.01	1.66	1.67	$0.72	$172.03	$172.75
2011	0.01	1.66	1.67	$0.70	$168.31	$169.01
2012	0.01	1.66	1.67	$0.69	$164.93	$165.62

FMVSS No. 139, New pneumatic radial tires for light vehicles

FMVSS No. 139 took effect on June 5, 2003, and specifies tire dimensions, test requirements, labeling requirements, and defines load ratings. The purpose of the standard is to create more stringent tire performance requirements and require improved labeling of tires to assist consumers in identifying tires that may be the subject of a safety recall. This standard applies to new pneumatic tires for use on motor vehicles (other than motorcycles and low speed vehicles) that have a GVWR of 10,000 pounds or less and that were manufactured after 1975. The new standard increased the stringency of the high-speed and endurance tests and added a new low-pressure test. No teardown cost studies have been performed. However, cost estimates were made in the Preliminary Economic Assessment[56] that accompanied the Notice of Proposed Rulemaking, and were open to comment, and then final estimates were made in the Final Regulatory Evaluation.[57] NHTSA estimated between 5 and 11 percent of the pre-standard tires in 2002 would have failed if they had been tested to the FMVSS No. 139. For this analysis we assumed the midpoint that 8 percent of the tires would have failed in 2002. In the Final Regulatory Evaluation, it was estimated that the average vehicle cost for a vehicle equipped with non-complying tires would have increased by a range $1.26 to $5.02 in 2012 dollars per vehicle in 2003 if it had instead been equipped with complying tires (passenger car or LTV). For this analysis we assumed that the average cost per vehicle for those failing the tire test would be the mid-point of the range of estimates or $3.14. Thus, for the average passenger car and LTV the increased cost was $0.25 ($3.14*0.08). There was no information indicating that FMVSS 139 would increase the weight of tires for either passenger cars or LTVs.

The final rule on FMVSS No. 139 was published in the Federal Register on June 26, 2003, (68 FR 38116) for tires on passenger cars and LTVs. The NPRM was published in the Federal Register on March 5, 2002, (67 FR 10050) making the baseline date September 1, 2001, or MY 2002.

We decided not to apply any voluntary costs for FMVSS No. 139. There is no typical countermeasure or tire feature needed to make those 2002 tires that failed the proposed new standards be able to pass the test. NHTSA’s tire experts believed different fixes were necessary for almost every different tire that failed. Tire designs are somewhat different. Thus, it is impossible to estimate a cost that passing tires voluntarily had built into their designs. In addition NHTSA has no data on pre-2002 tires to determine what percent would have passed the eventual final rule. Thus, the only information available is the estimated costs that are attributable to the final rule.

The learning curve for FMVSS No. 139 had to be adjusted to take into account the total number of tires sold in a year, rather than the total number of vehicles sold in a year, since replacement tires also had to meet the standard. The Final Regulatory Evaluation estimated that there are 287 million tires sold per year that would have to meet the standard. Since tire molds last about 5 years, the start of the learning curve was assumed to be in 1998 with 92 percent of the tires

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[56] NHTSA, *Preliminary Economic Assessment, Proposed New Pneumatic Tires for Light Vehicles, FMVSS No. 139*, October 2001, Docket No, 2000-8011-0029. NPRM published on March 5, 2002, (67 FR 10050).

[57] NHTSA, *Final Regulatory Evaluation, FMVSS 139, New Pneumatic Tires for Light Vehicles*, June 2003, Docket No. 2003-15400-2. Final Rule published on June 26, 2003, (68 FR 38116).

meeting the new requirements. The result of applying the learning curve was a rather slow decrease in costs per year from $0.25 attributable per vehicle starting in MY 2003 to $0.23 per vehicle in MY 2012.

Table 139-1 Average Weight (lb) and Cost (2012$) Attributable to Upgraded Tire Standard FMVSS No. 139 Passenger Cars and LTVs				
Model Year	PC Weight	PC Cost	LTV Weight	LTV Cost
2003	0	$0.25	0	$0.25
2004	0	$0.25	0	$0.25
2005	0	$0.24	0	$0.24
2006	0	$0.24	0	$0.24
2007	0	$0.24	0	$0.24
2008	0	$0.24	0	$0.24
2009	0	$0.23	0	$0.23
2010	0	$0.23	0	$0.23
2011	0	$0.23	0	$0.23
2012	0	$0.23	0	$0.23

SECTION 3 – FMVSS 200 SERIES

The FMVSS 200 series of crashworthiness standards specify performance requirements for motor vehicles intended to reduce the fatality risk or injury severity of people involved in crashes. Performance specifications are more easily related to specific hardware modifications than in the FMVSS 100 series of standards. Furthermore, most crashworthiness standards result in modification to equipment that requires no action by the driver or passenger. A noted exception of this condition is the use of seat belts that often requires the occupant to buckle up.

FMVSS No. 201, Occupant protection in interior impact

Original Standard. FMVSS No. 201 took effect on January 1, 1968, (passenger cars) and September 1, 1981 (multipurpose passenger vehicles, trucks, and buses) and specifies requirements on the design and performance of instrument panels, seat backs, interior compartment doors, sun visors, and armrests. The purpose of this standard is to afford head impact protection for occupants. Therefore, in order to meet the requirements, certain parts of the vehicle interior have to be padded, and no sharp or pointed parts can be placed in the vehicle interior that an occupant can come in contact with during a frontal crash. This standard applies to passenger cars, multipurpose passenger vehicles, trucks, (all LTVs), and buses with a GVWR of 10,000 pounds or less.

FMVSS No. 201 established impact test requirements for various interior surfaces, which may or may not have required some degree of modification to meet the tests. As a result, the cost analysis for FMVSS No. 201 was sometimes exploratory in nature. Since we did not know in advance if anything was changed to meet FMVSS No. 201, we had to discover this during the analysis.

Several pre- and post-standard specimens were compared for each of the various interior structures addressed by the standard. In some structures, costs might be consistently higher for the post-standard specimens, as evidenced by a statistically significant average cost increase for the study sample. That probably indicates they were modified because of the standard. In other structures, costs went up in some specimens and down in others, but the average change in cost was not statistically significant. That probably indicates the modifications were merely for styling or production efficiency, and not needed for meeting the standard. Of course, in those cases where a specific modification was already known to be associated with FMVSS No. 201 (e.g., the change from friction to mechanical latches on glove compartment doors), the exploratory approach was unnecessary and we were able to cost those modifications directly.

In some structures, like the instrument panel of passenger cars, manufacturers began padding interior surfaces well before the rulemaking process, as early as 1956. Each of the original components covered by FMVSS No. 201 is discussed below. Note that FMVSS 201 was significantly upgraded in 1995 to include upper interior components with the final rule phased-in effective date in MY 2003 for 100 percent of all passenger cars and LTVs. Costs for this upgrade are examined later in this report.

One of the most important developments from 1967 to 1971 (i.e., during and after the FMVSS No. 201 rulemaking period) was the reduction in the rigidity of the middle and lower instrument panels. The middle and lower panels were redesigned to deform at a controlled rate during an impact to reduce peak loads on an occupant's chest and legs. The availability of plastics, coupled with the desire to substitute them for steel to lighten vehicles, also led to less rigid panels. These improvements significantly reduced fatality and injury risk of right front passengers in crashes.[58] Since none of these modifications were necessitated or even addressed by FMVSS No. 201, their costs were not studied by NHTSA.

Passenger Car Studies

The final rule for passenger cars was published in the Federal Register on February 3, 1967, (32 FR 2414). The NPRM was published in the Federal Register on December 3, 1966, (31 FR 15212) making the baseline date September 1, 1966, or MY 1967.

Thirty passenger cars representing 10 make/models of pre-standard (1967), standard (1968), and post-standard (1969) systems were studied to determine the weight and consumer cost impact of FMVSS No. 201.[59] The following items were studied:

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[58] Kahane, C. J. (1988). *An evaluation of occupant protection in frontal interior impact for unrestrained front seat occupants of cars and lights trucks* (Report No. DOT HS 807 203). Washington, DC: National Highway Traffic Safety Administration.

[59] Gladstone, Harvey, & Lesczhik, DOT HS 806 367, 1982, Docket No. 2011-0066-0063.

Glove Box Compartment Doors. These were required by FMVSS No. 201 to remain in the closed position when subjected to an inertial load of 10g in the lateral and vertical directions, 30g in the longitudinal direction, or a head-on vehicle impact into a fixed barrier at 30 mph. A mechanical latch and striker with a release knob/button and mechanism was employed by the vehicle manufacturers to keep the door closed. Based on the teardown study, most passenger cars (79%) were already in compliance in the pre-standard MY 1967, and their glove compartment door locks were identical in design and manufacturing processing for the pre-standard, standard, and post-standard model years. Those vehicles not in compliance in MY 1967 used a friction latch, which was nothing more than a tab or tang mount to the inside of the door that pressed against an indentation on the inside of the glove compartment. The friction force was enough to keep the door closed during normal operation of the vehicle but not during a crash. Those vehicles with the friction latch in MY 1967 switched to a positive mechanical latch in MY 1968. The arithmetic average weight and consumer cost increase from the pre-standard to the post-standard vehicles was 0.05 pounds and $0.89 in 2012 dollars in the cars that changed from friction to mechanical latches. Since 100 percent of the fleet did not meet FMVSS No. 201 by the baseline date, costs would be considered voluntary through MY 1967 and the voluntary percentage will be held at that MY 1967 baseline level through MY 2012. Attributable costs will be the difference between the installation rates for MY 1968 to MY 2012 minus the voluntary baseline level of MY 1967. When these amounts are averaged with the rest of the fleet (unchanged), the average weight and consumer cost increases for the entire fleet are 0.01 pounds and $0.19 in 2012 dollars and are attributed to the standard. Voluntary compliance for MY 1968 to MY 2012 is 0.04 pounds and $0.70. Both of these estimates are before applying the learning curve.

Protruding Components (Interior Door Release Handles, Window Regulators, and Vent Window Locks and Regulators). These were considered protrusions according to the original proposed FMVSS No. 201. The underlying concept of the proposed requirement was to re-contour, soften (change material or add padding), recess, or move the interior items that protruded into possible head, knee, or leg impact areas. This requirement was later removed in an amendment in the summer of 1967. Even though the protrusion requirement was dropped, vehicle manufacturers made changes to comply with the proposed requirements. The year 1968 was a transitional stage that reflected some uncertainty on design changes. By 1969 the cost of these systems was, on the average, lower (but not significantly lower) than in 1966. Window regulators were re-contoured with larger radii, using more pliable plastic or rubber knobs in place of the smaller metal knobs. This resulted in a decrease in consumer cost of $1.80 in 2012 dollars. Interior door release handles were reshaped with fewer sharp edges and corners and built into either the armrest or flush with the door inner trim panel, which decreased the consumer cost by $1.02 in 2012 dollars. Vent window locks were either eliminated or reshaped to be smaller and rounder, with many vehicles eliminating the vent window on the 1968 and 1969 make-models. Since the changes to the protruding components were not required, the weight and consumer cost difference is not attributed to the standard. Even if FMVSS No. 201 had required this modification, this report would not have credited the cost reduction to the standard because the same cost-saving modifications could presumably have been implemented without it.

Armrests. These were required to deflect or collapse laterally upon impact at least 2 inches without contacting any underlying rigid material or have no unpadded areas that a passenger could contact in a collision. Many armrests were redesigned to be longer and shallower in order to protrude less into the pelvic impact area. Additional padding, support structure, and softer cover materials were also employed for the 1968 and 1969 model years. However, the cost of these additions was in some cases more than offset by the reduction in the overall size of the armrest. The average change in weight and consumer cost from the pre-standard to the post-standard vehicles was an increase of 0.06 pounds and a decrease of $0.41 in 2012 dollars. These weight and cost changes were not statistically significant since half of the armrests studied increased and half decreased. Since no consistent trend was demonstrated, the changes in the weight and cost of armrests are not attributed to the standard.

Sun Visors. FMVSS No. 201 required two sun visors be provided that were constructed of, or covered with, energy absorbing materials. No rigid material edge radii less than 0.125 inches would be present on the sun visor mounting. The manufacturers made the required design and material changes, but these did not necessarily lead to increased costs. In fact, the average weight and consumer cost decreased from the pre-standard to the post-standard vehicles by 0.15 pounds and $0.57 in 2012 dollars. Since approximately half of the sun visors studied decreased in weight and cost while the other half increased, the difference between the 1967 and 1969 model years is not statistically significant. Since no consistent trend was demonstrated, the changes in the weight and cost of sun visors are not attributed to the standard.

Instrument Panels. These were required to have adequate energy absorption capabilities in head impact areas (primarily the top surface and edges of the panel) so that when a 15-pound, 6.5-inch diameter head form is impacted at a velocity of 15 miles per hour the deceleration rate does not exceed 80g continuously for more than 3 milliseconds. Changes to the padding and the instrument panel cover were made for the 1968 and 1969 model years. The average weight increased from the pre-standard to the post-standard vehicles by 0.87 pounds while the consumer cost decreased by $1.02 in 2012 dollars. Just over half of the instrument panels studied increased in weight and decreased in cost. The average weight and consumer cost difference between the 1967 and 1969 model years are not statistically significant. Since no consistent trend was demonstrated, the changes in the weight and cost of instrument panels for passenger cars are not attributed to the standard.

Seat Back Padding. Similar to instrument panels, the head impact areas of the front seat backs are required to pass a head form impact test. The requirement applies to the top and backside of the front seat back, which are impact areas for the back-seat occupant in a frontal crash. The upper six inches of the front seat back padding was studied. All ten of the make/models inspected in the teardown study increased seat back padding between MY 1967 and MY 1968, indicating that no models passed during the baseline year of 1967. Thus, we assume no voluntary compliance for MY 1967. The average weight and consumer cost increased in the all ten specimen make-models from MY 1967 to MY 1968 and in seven specimen make-models from 1968 to 1969. The average weight and consumer cost increase from MY 1967 to MY 1969 was 0.65 pounds and $5.33 in 2012 dollars and is attributed to the standard.

Table 201-1 shows the total average weight and consumer cost increase of occupant protection for FMVSS No. 201 in passenger cars before applying the learning curve. Three separate learning curves were analyzed for passenger cars and LTVs to analyze all the necessary improvements to FMVSS No. 201. These learning curves were for the glove box latch, instrument panel (which was not needed for passenger cars), and seat back padding.

TABLE 201-1 AVERAGE WEIGHT AND CONSUMER COST OF OCCUPANT PROTECTION COUNTERMEASURES FOR FMVSS No. 201 IN PASSENGER CARS		
COMPONENT	**WEIGHT IN POUNDS**	**CONSUMER COST ($2012)**
Glove Box Door Latch	0.05	$0.89
Seat Back Padding	0.65	$5.33
TOTAL	0.70	$6.22

An additional study was conducted in the 1980s to determine the cost effect (trend cost) that FMVSS No. 201 had on 1983 passenger cars plus the effect that downsizing, weight reduction, and front-wheel drive may have had on the cost of implementing the standard.[60] The basis for the price determinations was the teardown and analysis of system components from selected vehicles representing comparable make-models prior to and after the effective date of the standard. Since the trend-system sample did not measure the same items or car designs as the pre- and post-standard sample, the costs cannot be used for comparison.

Tables 201-2 and 201-3 show the average weight and consumer cost increases for passenger cars after applying the learning curve and the distribution between voluntary and attributable weights and costs. There is no need to provide a separate table to show the weight and cost after the learning curve since it is the same as the totals shown in Table 201-2. Since the effective date is MY 1968, 100 percent of passenger cars met the glove box and seat back standard.

Table 201-2 FMVSS No. 201 Glove Box - Passenger Cars						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	0.04	0.01	0.05	$0.70	$0.19	$0.89
1969	0.04	0.01	0.05	$0.67	$0.18	$0.85
1970	0.04	0.01	0.05	$0.65	$0.17	$0.82
1971	0.04	0.01	0.05	$0.63	$0.17	$0.80
1972	0.04	0.01	0.05	$0.62	$0.17	$0.79
1973	0.04	0.01	0.05	$0.61	$0.16	$0.77
1974	0.04	0.01	0.05	$0.60	$0.16	$0.76
1975	0.04	0.01	0.05	$0.59	$0.16	$0.75
1976	0.04	0.01	0.05	$0.59	$0.16	$0.74

[60] Osen, W. R., &Ludtke, N. F. (1985, April). *Cost evaluation of Federal Motor Vehicle Safety Standard 210 – passenger cars and evaluation of cost and weight trends for Standards 201, 203, and 204 – Passenger cars, Volume I* (Report No. DOT HS 806 770). Washington, DC: National Highway Traffic Safety Administration, Docket No. 2011-0066-0052.

1977	0.04	0.01	0.05	$0.58	$0.15	$0.74
1978	0.04	0.01	0.05	$0.57	$0.15	$0.73
1979	0.04	0.01	0.05	$0.57	$0.15	$0.72
1980	0.04	0.01	0.05	$0.56	$0.15	$0.71
1981	0.04	0.01	0.05	$0.56	$0.15	$0.71
1982	0.04	0.01	0.05	$0.56	$0.15	$0.70
1983	0.04	0.01	0.05	$0.55	$0.15	$0.70
1984	0.04	0.01	0.05	$0.55	$0.15	$0.69
1985	0.04	0.01	0.05	$0.54	$0.14	$0.69
1986	0.04	0.01	0.05	$0.54	$0.14	$0.68
1987	0.04	0.01	0.05	$0.53	$0.14	$0.68
1988	0.04	0.01	0.05	$0.53	$0.14	$0.67
1989	0.04	0.01	0.05	$0.53	$0.14	$0.67
1990	0.04	0.01	0.05	$0.53	$0.14	$0.66
1991	0.04	0.01	0.05	$0.52	$0.14	$0.66
1992	0.04	0.01	0.05	$0.52	$0.14	$0.66
1993	0.04	0.01	0.05	$0.52	$0.14	$0.66
1994	0.04	0.01	0.05	$0.52	$0.14	$0.65
1995	0.04	0.01	0.05	$0.51	$0.14	$0.65
1996	0.04	0.01	0.05	$0.51	$0.14	$0.65
1997	0.04	0.01	0.05	$0.51	$0.14	$0.64
1998	0.04	0.01	0.05	$0.51	$0.13	$0.64
1999	0.04	0.01	0.05	$0.50	$0.13	$0.64
2000	0.04	0.01	0.05	$0.50	$0.13	$0.64
2001	0.04	0.01	0.05	$0.50	$0.13	$0.63
2002	0.04	0.01	0.05	$0.50	$0.13	$0.63
2003	0.04	0.01	0.05	$0.50	$0.13	$0.63
2004	0.04	0.01	0.05	$0.49	$0.13	$0.63
2005	0.04	0.01	0.05	$0.49	$0.13	$0.62
2006	0.04	0.01	0.05	$0.49	$0.13	$0.62
2007	0.04	0.01	0.05	$0.49	$0.13	$0.62
2008	0.04	0.01	0.05	$0.49	$0.13	$0.62
2009	0.04	0.01	0.05	$0.49	$0.13	$0.62
2010	0.04	0.01	0.05	$0.49	$0.13	$0.62
2011	0.04	0.01	0.05	$0.49	$0.13	$0.61
2012	0.04	0.01	0.05	$0.48	$0.13	$0.61

Table 201-3						
FMVSS No. 201 Seat Back Padding - Passenger Cars						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	0.00	0.65	0.65	$0.00	$5.33	$5.33
1969	0.00	0.65	0.65	$0.00	$4.97	$4.97
1970	0.00	0.65	0.65	$0.00	$4.79	$4.79
1971	0.00	0.65	0.65	$0.00	$4.64	$4.64
1972	0.00	0.65	0.65	$0.00	$4.53	$4.53
1973	0.00	0.65	0.65	$0.00	$4.43	$4.43
1974	0.00	0.65	0.65	$0.00	$4.37	$4.37
1975	0.00	0.65	0.65	$0.00	$4.32	$4.32
1976	0.00	0.65	0.65	$0.00	$4.26	$4.26
1977	0.00	0.65	0.65	$0.00	$4.21	$4.21
1978	0.00	0.65	0.65	$0.00	$4.16	$4.16
1979	0.00	0.65	0.65	$0.00	$4.12	$4.12
1980	0.00	0.65	0.65	$0.00	$4.09	$4.09
1981	0.00	0.65	0.65	$0.00	$4.06	$4.06
1982	0.00	0.65	0.65	$0.00	$4.03	$4.03
1983	0.00	0.65	0.65	$0.00	$4.00	$4.00
1984	0.00	0.65	0.65	$0.00	$3.96	$3.96
1985	0.00	0.65	0.65	$0.00	$3.93	$3.93
1986	0.00	0.65	0.65	$0.00	$3.90	$3.90
1987	0.00	0.65	0.65	$0.00	$3.87	$3.87
1988	0.00	0.65	0.65	$0.00	$3.84	$3.84
1989	0.00	0.65	0.65	$0.00	$3.82	$3.82
1990	0.00	0.65	0.65	$0.00	$3.79	$3.79
1991	0.00	0.65	0.65	$0.00	$3.78	$3.78
1992	0.00	0.65	0.65	$0.00	$3.76	$3.76
1993	0.00	0.65	0.65	$0.00	$3.74	$3.74
1994	0.00	0.65	0.65	$0.00	$3.72	$3.72
1995	0.00	0.65	0.65	$0.00	$3.70	$3.70
1996	0.00	0.65	0.65	$0.00	$3.69	$3.69
1997	0.00	0.65	0.65	$0.00	$3.67	$3.67
1998	0.00	0.65	0.65	$0.00	$3.66	$3.66
1999	0.00	0.65	0.65	$0.00	$3.64	$3.64
2000	0.00	0.65	0.65	$0.00	$3.62	$3.62
2001	0.00	0.65	0.65	$0.00	$3.61	$3.61
2002	0.00	0.65	0.65	$0.00	$3.59	$3.59
2003	0.00	0.65	0.65	$0.00	$3.58	$3.58

2004	0.00	0.65	0.65	$0.00	$3.57	$3.57
2005	0.00	0.65	0.65	$0.00	$3.55	$3.55
2006	0.00	0.65	0.65	$0.00	$3.54	$3.54
2007	0.00	0.65	0.65	$0.00	$3.53	$3.53
2008	0.00	0.65	0.65	$0.00	$3.52	$3.52
2009	0.00	0.65	0.65	$0.00	$3.51	$3.51
2010	0.00	0.65	0.65	$0.00	$3.51	$3.51
2011	0.00	0.65	0.65	$0.00	$3.50	$3.50
2012	0.00	0.65	0.65	$0.00	$3.49	$3.49

LTV Studies

The final rule extending FMVSS No. 201 to LTVs was published in the Federal Register on November 29, 1979, (44 FR 68470). The NPRM was published in the Federal Register on November 9, 1978 (43 FR 52264), making the baseline date September 1, 1978 or MY 1979.

A study was conducted in 1979 on MY 1979 LTVs to determine the effects of extending the passenger car requirements of FMVSS No. 201 to LTVs.[61] An estimate of the additional weight and consumer cost imposed by the standard on LTVs was calculated to support the regulatory analysis process; however, these estimates were not based on a teardown analysis. All MY 1979 U.S. LTVs and the Nissan and Toyota pickups were inspected to determine their state of compliance. Cost and weight estimates were prepared for all items that were in noncompliance.

Glove Box Compartment Doors. The teardown study of MY 1979 LTVs found that a sales weighted 50 percent of glove box doors met the standard. However, NHTSA has no information to help it determine the percentage of voluntary compliance before MY 1979. Without any knowledge we will not assume any voluntary compliance prior to MY 1979. We assume 50 percent compliance in MY 1980 and MY 1981, and then 100 percent compliance in MY 1982, the effective date of FMVSS No. 201 for LTVs. The average cost of a glove box latch for LTVs was $0.46 (in 2012 dollars) and the weight was not estimated. We will assume the same weight (0.05 lb)). as found in the passenger car teardown study.

Protruding Components (Interior Door Release Handles, Window Regulators, and Vent Window Locks and Regulators). These were not studied in the LTV cost report, since the passenger car study found them to be less costly after the standard.

Armrests. All but one of the armrests complied with the standard in the baseline year. The one armrest that did not comply could have been moved to a slightly different position on the door to make it comply with no cost or it could have added padding. For this analysis we are assuming the no cost option could have been taken.

[61] McLean, R. F. (1979, May). *Study of the effects of applying Federal Motor Vehicle Safety Standard 201 to LTVs and vans* (Report No. DOT HS 805 162). Washington, DC: National Highway Traffic Safety Administration, Docket No. 2011-0066-0078.

Sun Visors. All of the sun visors in the baseline fleet complied with the standard. Thus, no weight or costs are estimated for sun visors.

Instrument Panels. Unlike passenger cars, many of the LTVs needed padding added to their instrument panel to comply with the standard. A sales weighted estimated 41.7 percent complied with the standard. For each of the non-complying make/models the area that needed to be padded on the instrument panel was determined, and padding and a cover were assumed to cover this area, with resulting weight and cost estimates. For those vehicles that needed instrument panel padding, the average weight increase was 3.02 lb. and the average consumer cost increase was $16.00 in 2012 dollars. Since it is likely that instrument panel padding would only change with a new model, unless required by a standard, and LTV models aren't updated as often as passenger cars, we assume a steady increase in the percentage of vehicles with compliant instrument panels from MY 1976 as shown in Table 201-4.

Seat Back Padding. None of the MY 1979 LTVS met the seat back padding requirements and additional padding was required on all applicable seat backs. Pickups equipped to carry rear-seat passengers would require added seat back padding on the front seat. Passenger vans, fitted with one or more seats behind the front seats, would require the forward-most seat backs to be padded. The sales weighted average weight and consumer cost increase of padding for LTVs was 1.28 lb. and $6.82, which will be applied to 83.3 percent of the LTVs, because 16.7 percent did not have rear seats, resulting in an average for LTVs of 1.07 lb. and $5.68. The 16.7 percent figure is the best estimates, based on the contractor's judgment. Table 201-4 presents the estimated percentage of the passenger car and LTV new vehicles that complied with the standard.

Table 201-4
Estimated Compliance (in%)
FMVSS No. 201 - LTVs by Model Year

Model Year	Glove Box	Instru. Panel	Seat Back
pre-1975	0	0	0
1976	0	10	0
1977	0	20	0
1978	0	30	0
1979	50	41.7	0
1980	50	50	10
1981	50	60	20
1982	100	100	100
post-1982	100	100	100

TABLE 201-5 AVERAGE WEIGHT AND CONSUMER COST OF OCCUPANT PROTECTION COUNTERMEASURES FOR FMVSS No. 201 IN LTVs		
COMPONENT	**WEIGHT IN POUNDS**	**CONSUMER COST ($2012)**
Glove Box Door Latch	0.05	$0.46
Instrument Panel Padding	3.02	$16.00
Seat Back Padding	1.07	$5.68
TOTAL	4.14	$22.14

A study of the interior components on seven 1982 model year LTVs was conducted to determine the consumer cost and weight of the glove box latches, dashboard padding, armrests, and sun visors.[62] No pre-standard make-models were studied to serve as a baseline. The 1982 specimen vehicles were leased for visual inspection, detailed measurements, and photographic documentation, but components were not removed and torn down. However, because some of the make-models were extensively redesigned in 1982, the contractor was unable to directly compare the components of pre- and post-standard LTVs and did not estimate the average cost increase.

Table 201-6, Table 201-7, Table 201-8 present the weight and cost estimates after applying the learning curve and the distribution between voluntary and attributable weights and costs.

Table 201-6 FMVSS No. 201 Glove Box Latch - LTVs						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	0.000	0.000	0.00	$0.00	$0.00	$0.00
1969	0.000	0.000	0.00	$0.00	$0.00	$0.00
1970	0.000	0.000	0.00	$0.00	$0.00	$0.00
1971	0.000	0.000	0.00	$0.00	$0.00	$0.00
1972	0.000	0.000	0.00	$0.00	$0.00	$0.00
1973	0.000	0.000	0.00	$0.00	$0.00	$0.00
1974	0.000	0.000	0.00	$0.00	$0.00	$0.00
1975	0.000	0.000	0.00	$0.00	$0.00	$0.00
1976	0.000	0.000	0.00	$0.00	$0.00	$0.00
1977	0.000	0.000	0.00	$0.00	$0.00	$0.00
1978	0.000	0.000	0.00	$0.00	$0.00	$0.00
1979	0.025	0.000	0.03	$0.23	$0.00	$0.23
1980	0.025	0.000	0.03	$0.23	$0.00	$0.23

[62] Gladstone, Harvey, Lesczhik, & McLean, 1982, Docket No. 2011-0066-0053.

1981	0.025	0.000	0.03	$0.23	$0.00	$0.23
1982	0.025	0.025	0.05	$0.23	$0.23	$0.45
1983	0.025	0.025	0.05	$0.22	$0.22	$0.45
1984	0.025	0.025	0.05	$0.22	$0.22	$0.45
1985	0.025	0.025	0.05	$0.22	$0.22	$0.44
1986	0.025	0.025	0.05	$0.22	$0.22	$0.44
1987	0.025	0.025	0.05	$0.22	$0.22	$0.44
1988	0.025	0.025	0.05	$0.22	$0.22	$0.43
1989	0.025	0.025	0.05	$0.21	$0.21	$0.43
1990	0.025	0.025	0.05	$0.21	$0.21	$0.43
1991	0.025	0.025	0.05	$0.21	$0.21	$0.43
1992	0.025	0.025	0.05	$0.21	$0.21	$0.42
1993	0.025	0.025	0.05	$0.21	$0.21	$0.42
1994	0.025	0.025	0.05	$0.21	$0.21	$0.42
1995	0.025	0.025	0.05	$0.21	$0.21	$0.42
1996	0.025	0.025	0.05	$0.21	$0.21	$0.42
1997	0.025	0.025	0.05	$0.21	$0.21	$0.41
1998	0.025	0.025	0.05	$0.21	$0.21	$0.41
1999	0.025	0.025	0.05	$0.21	$0.21	$0.41
2000	0.025	0.025	0.05	$0.20	$0.20	$0.41
2001	0.025	0.025	0.05	$0.20	$0.20	$0.41
2002	0.025	0.025	0.05	$0.20	$0.20	$0.41
2003	0.025	0.025	0.05	$0.20	$0.20	$0.40
2004	0.025	0.025	0.05	$0.20	$0.20	$0.40
2005	0.025	0.025	0.05	$0.20	$0.20	$0.40
2006	0.025	0.025	0.05	$0.20	$0.20	$0.40
2007	0.025	0.025	0.05	$0.20	$0.20	$0.40
2008	0.025	0.025	0.05	$0.20	$0.20	$0.40
2009	0.025	0.025	0.05	$0.20	$0.20	$0.40
2010	0.025	0.025	0.05	$0.20	$0.20	$0.40
2011	0.025	0.025	0.05	$0.20	$0.20	$0.40
2012	0.025	0.025	0.05	$0.20	$0.20	$0.39

Table 201-7						
FMVSS No. 201 Instrument Panel - LTVs						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	0.00	0.00	0.00	$0.00	$0.00	$0.00
1969	0.00	0.00	0.00	$0.00	$0.00	$0.00
1970	0.00	0.00	0.00	$0.00	$0.00	$0.00
1971	0.00	0.00	0.00	$0.00	$0.00	$0.00
1972	0.00	0.00	0.00	$0.00	$0.00	$0.00
1973	0.00	0.00	0.00	$0.00	$0.00	$0.00
1974	0.00	0.00	0.00	$0.00	$0.00	$0.00
1975	0.00	0.00	0.00	$0.00	$0.00	$0.00
1976	0.30	0.00	0.30	$1.65	$0.00	$1.65
1977	0.60	0.00	0.60	$3.27	$0.00	$3.27
1978	0.91	0.00	0.91	$4.85	$0.00	$4.85
1979	1.26	0.00	1.26	$6.67	$0.00	$6.67
1980	1.26	0.25	1.51	$6.62	$1.32	$7.94
1981	1.26	0.55	1.81	$6.58	$2.89	$9.46
1982	1.26	1.76	3.02	$6.53	$9.13	$15.66
1983	1.26	1.76	3.02	$6.48	$9.06	$15.55
1984	1.26	1.76	3.02	$6.43	$8.99	$15.42
1985	1.26	1.76	3.02	$6.38	$8.92	$15.29
1986	1.26	1.76	3.02	$6.33	$8.84	$15.17
1987	1.26	1.76	3.02	$6.28	$8.78	$15.07
1988	1.26	1.76	3.02	$6.24	$8.73	$14.97
1989	1.26	1.76	3.02	$6.20	$8.67	$14.88
1990	1.26	1.76	3.02	$6.17	$8.63	$14.80
1991	1.26	1.76	3.02	$6.14	$8.59	$14.74
1992	1.26	1.76	3.02	$6.12	$8.55	$14.67
1993	1.26	1.76	3.02	$6.09	$8.51	$14.60
1994	1.26	1.76	3.02	$6.06	$8.47	$14.53
1995	1.26	1.76	3.02	$6.03	$8.43	$14.47
1996	1.26	1.76	3.02	$6.01	$8.40	$14.40
1997	1.26	1.76	3.02	$5.98	$8.36	$14.34
1998	1.26	1.76	3.02	$5.96	$8.33	$14.28
1999	1.26	1.76	3.02	$5.93	$8.29	$14.22
2000	1.26	1.76	3.02	$5.90	$8.25	$14.16
2001	1.26	1.76	3.02	$5.88	$8.22	$14.10
2002	1.26	1.76	3.02	$5.86	$8.19	$14.05
2003	1.26	1.76	3.02	$5.84	$8.16	$13.99

2004	1.26	1.76	3.02	$5.81	$8.13	$13.94
2005	1.26	1.76	3.02	$5.79	$8.10	$13.90
2006	1.26	1.76	3.02	$5.78	$8.07	$13.85
2007	1.26	1.76	3.02	$5.76	$8.05	$13.81
2008	1.26	1.76	3.02	$5.74	$8.03	$13.77
2009	1.26	1.76	3.02	$5.73	$8.01	$13.75
2010	1.26	1.76	3.02	$5.72	$8.00	$13.72
2011	1.26	1.76	3.02	$5.71	$7.98	$13.69
2012	1.26	1.76	3.02	$5.69	$7.96	$13.65

Table 201-8
FMVSS No. 201 Seat Back Padding - LTVs

Model Year	Weight (lb)			Consumer Cost (2012$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0.00	0.00	0.00	$0.00	$0.00	$0.00
1969	0.00	0.00	0.00	$0.00	$0.00	$0.00
1970	0.00	0.00	0.00	$0.00	$0.00	$0.00
1971	0.00	0.00	0.00	$0.00	$0.00	$0.00
1972	0.00	0.00	0.00	$0.00	$0.00	$0.00
1973	0.00	0.00	0.00	$0.00	$0.00	$0.00
1974	0.00	0.00	0.00	$0.00	$0.00	$0.00
1975	0.00	0.00	0.00	$0.00	$0.00	$0.00
1976	0.00	0.00	0.00	$0.00	$0.00	$0.00
1977	0.00	0.00	0.00	$0.00	$0.00	$0.00
1978	0.00	0.00	0.00	$0.00	$0.00	$0.00
1979	0.00	0.00	0.00	$0.00	$0.00	$0.00
1980	0.00	0.11	0.11	$0.00	$0.56	$0.56
1981	0.00	0.21	0.21	$0.00	$1.12	$1.12
1982	0.00	1.07	1.07	$0.00	$5.56	$5.56
1983	0.00	1.07	1.07	$0.00	$5.51	$5.51
1984	0.00	1.07	1.07	$0.00	$5.46	$5.46
1985	0.00	1.07	1.07	$0.00	$5.41	$5.41
1986	0.00	1.07	1.07	$0.00	$5.37	$5.37
1987	0.00	1.07	1.07	$0.00	$5.33	$5.33
1988	0.00	1.07	1.07	$0.00	$5.29	$5.29
1989	0.00	1.07	1.07	$0.00	$5.26	$5.26
1990	0.00	1.07	1.07	$0.00	$5.23	$5.23
1991	0.00	1.07	1.07	$0.00	$5.21	$5.21
1992	0.00	1.07	1.07	$0.00	$5.18	$5.18
1993	0.00	1.07	1.07	$0.00	$5.16	$5.16

1994	0.00	1.07	1.07	$0.00	$5.13	$5.13
1995	0.00	1.07	1.07	$0.00	$5.11	$5.11
1996	0.00	1.07	1.07	$0.00	$5.08	$5.08
1997	0.00	1.07	1.07	$0.00	$5.06	$5.06
1998	0.00	1.07	1.07	$0.00	$5.04	$5.04
1999	0.00	1.07	1.07	$0.00	$5.02	$5.02
2000	0.00	1.07	1.07	$0.00	$4.99	$4.99
2001	0.00	1.07	1.07	$0.00	$4.97	$4.97
2002	0.00	1.07	1.07	$0.00	$4.95	$4.95
2003	0.00	1.07	1.07	$0.00	$4.93	$4.93
2004	0.00	1.07	1.07	$0.00	$4.92	$4.92
2005	0.00	1.07	1.07	$0.00	$4.90	$4.90
2006	0.00	1.07	1.07	$0.00	$4.88	$4.88
2007	0.00	1.07	1.07	$0.00	$4.87	$4.87
2008	0.00	1.07	1.07	$0.00	$4.85	$4.85
2009	0.00	1.07	1.07	$0.00	$4.84	$4.84
2010	0.00	1.07	1.07	$0.00	$4.83	$4.83
2011	0.00	1.07	1.07	$0.00	$4.82	$4.82
2012	0.00	1.07	1.07	$0.00	$4.81	$4.81

Head Impact Protection Upgrade.

FMVSS No. 201 was substantially upgraded in August 1995 (60 FR 43031). A final rule was issued requiring passenger cars and LTVs to provide protection when an occupant's head strikes upper interior components during a crash, including pillars, side rails, headers, and the roof. The rule significantly expanded the scope of the standard. Previously, the standard applied mainly to the portion of the vehicle interior in front of the front seat occupants, i.e., the instrument panel. On August 4, 1998, (63 FR 41451) the standard was amended to permit, but not require, the installation of dynamically deploying upper interior head protection systems (window curtain air bags) that provide added head protection in lateral crashes. Recognizing that the 15 mph headform test might be a problem in target areas where an un-deployed air bag is stored (and, furthermore, an inappropriate test if the window curtain usually deploys at that speed), NHTSA offered an alternative compliance procedure. Manufacturers have the option to reduce the speed of the headform test to 12 mph on target areas where the bag is stored, provided they can also meet an 18 mph lateral (90-degree) crash test for the full vehicle into a pole – with HIC < 1000. The pole test simulates a head impact with the deployed bag.

Specific areas of the upper interior are required to absorb energy to protect the occupant's head in an impact. A free motion head form is propelled into target locations on the A-pillar, B-pillar, side headers, front windshield header, and other potential interior locations. The impact speed for the free-motion headform impact test for the new areas is 15 mph, as in the original FMVSS No. 201, but for these new targets, HIC may not exceed 1,000 for any 36-millisecond period. Impacts could be directed from a range of vertical and horizontal angles, not just head-on. The additional upper interior protection requirements can be met with or without head air bags. The upper interior head protection requirements were phased-in starting with the 1999 model year and all vehicles had to meet the standard with the 2003 model year. Manufacturers were offered a choice of several alternative phase-in schedules from September 1, 1998, to September 1, 2002. For example, phase-in schedule #1 specified that they certify to the new requirements on at least 10 percent of cars and LTVs manufactured from September 1, 1998, to August 31, 1999; at least 25 percent of cars and LTVs manufactured from September 1, 1999, to August 31, 2000; at least 40 percent of cars and LTVs manufactured from September 1, 2000, to August 31, 2001; at least 70 percent of cars and LTVs manufactured from September 1, 2001, to August 31, 2002; and all cars and LTVs manufactured on or after September 1, 2002.

The NPRM was published in the Federal Register on February 8, 1993, (58 FR 7506) making the baseline date September 1, 1992, or MY 1993. Since none of the fleet passed all of the requirements by MY 1994, we assume no voluntary compliance and all of the costs are attributable to the final rule.

A study was conducted in 2003 to determine the changes made by the automotive industry to meet the standard's criteria without window curtain air bags. Ten make-model pre-standard passenger vehicles (six passenger cars, one pickup, one SUV, and two vans), and their corresponding mostly MY 2001 post-standard systems, were studied to determine the weight and consumer cost impact of adding non air bag components.[63] The type of approaches used to meet the standard consist of foam padding, ridges molded from composite materials, injection molded egg-crate or honeycomb parts, and injection molded ribs in parallel on the interior side of trim pieces. All these approaches are used in the A and B pillar trim, header, and headliner locations.

The principal modifications needed to meet FMVSS No. 201 were the addition of energy-absorbing padding in the target areas noted above and the addition of window curtain air bags. In most make-models of cars and LTVs, padding came first, window curtains usually came later. It is generally unknown to what extent the padding stayed the same in vehicles after the window curtains arrived. Some modification or even discontinuation of the padding may occur in components that house the window curtains, such as the roof side rails, or possibly in areas that may be protected by window curtains, such as pillars. NHTSA studied the pillar components in three make-models certified to the head-impact upgrade of FMVSS No. 201, before and after these models were equipped with window curtains; the average cost of the components was slightly higher in the vehicles with the window curtains, suggesting (although not proving) that energy-absorbing materials were not downgraded, at least on these three models, after window curtains became available.[64]

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[63] Ludtke, N. F., Osen, W., Gladstone, R., & Lieberman, W. (2003). Perform cost and weight analysis, non-air Bag head protection systems, FMVSS 201. (Report No. DOT HS 809 810). Washington, DC: National Highway Traffic Safety Administration, Docket No. 2011-0066-0008.

[64] Kahane, C. J. (2011, November). *Evaluation of the 1999-2003 head impact upgrade of FMVSS No. 201 – upper-interior components: effectiveness of energy-absorbing materials without head-protection air bags* (Report No. DOT HS 811 538). Washington, DC: National Highway Traffic Safety Administration. Available at www-nrd.nhtsa.dot.gov/Pubs/811538.pdf; Ludtke, N. F., Osen, W., Gladstone, R., & Lieberman, W. (2004, December). *Perform cost and weight analysis, head protection air bag systems, FMVSS 201* (Report No. DOT HS 809 842; NHTSA Docket No. NHTSA-2011-0066-0007, pp. 3-47 to 3-54 and Appendix A). Washington, DC: National Highway Traffic Safety Administration.

Table 201-9 shows the sales-weighted average weight and consumer cost of the protection systems without window curtain air bags derived from Ludtke 2003, before applying the learning curve. The data for passenger cars and LTVs was combined to estimate a single average cost.

TABLE 201-9 AVERAGE WEIGHT AND CONSUMER COST INCREASE OF HEAD IMPACT PROTECTION SYSTEMS WITHOUT AIR BAGS IN PASSENGER CARS AND LTVS		
SYSTEM	**WEIGHT IN POUNDS**	**CONSUMER COST ($2012)**
Without Air Bags	1.89	$14.80

This cost is inherently attributable to FMVSS No. 201. Table 201-10 shows the percentage of the fleet that met the standard by model year based on NHTSA test data and compliance data supplied by the manufacturers to NHTSA during the phase-in years and Table 201-11 and Table 201-12 show the average increase in passenger car and LTV weight and consumer cost by model year. Costs start to decline after the new vehicle fleet is 100 percent equipped due to learning and progress rate of 0.93.

Table 201-10 Estimated Percent Compliance with FMVSS No. 201 Upper Interior Head Protection - Non-Air-Bag Passenger Cars and LTVs		
Model Year	**Passenger Cars**	**LTVs**
Pre 1999	0	0
1999	20.53	15
2000	47.54	28.22
2001	63.43	35.47
2002	71.55	75.6
After 2002	100	100

Table 201-11 Average Weight (lb) and Cost (2012$) of Upper Interior Head Protection - Non-Air-Bag Passenger Cars						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1998	0	0	0	0	0	0
1999	0	0.39	0.39	0	$3.66	$3.66
2000	0	0.90	0.90	0	$7.52	$7.52
2001	0	1.20	1.20	0	$9.39	$9.39
2002	0	1.35	1.35	0	$10.03	$10.03
2003	0	1.89	1.89	0	$13.39	$13.39
2004	0	1.89	1.89	0	$12.96	$12.96
2005	0	1.89	1.89	0	$12.65	$12.65
2006	0	1.89	1.89	0	$12.40	$12.40
2007	0	1.89	1.89	0	$12.21	$12.21
2008	0	1.89	1.89	0	$12.07	$12.07
2009	0	1.89	1.89	0	$11.97	$11.97
2010	0	1.89	1.89	0	$11.87	$11.87
2011	0	1.89	1.89	0	$11.77	$11.77
2012	0	1.89	1.89	0	$11.66	$11.66

Table 201-12						
Average Weight (lb) and Cost (2012$) of						
Upper Interior Head Protection - Non-Air-Bag						
LTVs						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1998	0	0	0	0	0	0
1999	0	0.28	0.28	0	$2.68	$2.68
2000	0	0.53	0.53	0	$4.46	$4.46
2001	0	0.67	0.67	0	$5.25	$5.25
2002	0	1.43	1.43	0	$10.59	$10.59
2003	0	1.89	1.89	0	$13.39	$13.39
2004	0	1.89	1.89	0	$12.96	$12.96
2005	0	1.89	1.89	0	$12.65	$12.65
2006	0	1.89	1.89	0	$12.40	$12.40
2007	0	1.89	1.89	0	$12.21	$12.21
2008	0	1.89	1.89	0	$12.07	$12.07
2009	0	1.89	1.89	0	$11.97	$11.97
2010	0	1.89	1.89	0	$11.87	$11.87
2011	0	1.89	1.89	0	$11.77	$11.77
2012	0	1.89	1.89	0	$11.66	$11.66

FMVSS No. 202, Head restraints

On February 14, 1968, (33 FR 2945) a final rule was published in the Federal Register for passenger car head restraints. On September 25, 1989, (54 FR 39183) a final rule extended the requirements to LTVs.

FMVSS No. 202 took effect on January 1, 1969, (passenger cars) and September 1, 1991, (multipurpose passenger vehicles, trucks, all LTVs, and buses) and specifies requirements for head restraints at the front outboard seat positions. The purpose of this standard is to reduce the frequency and severity of neck injuries in rear-end and other collisions, specifically whiplash, a painful and sometimes disabling syndrome that is all too common in these crashes. This standard applies to passenger cars, multipurpose passenger vehicles, trucks, (all LTVs), and buses with a GVWR of 10,000 pounds or less.

The NPRM for passenger cars was published in the Federal Register on December 28, 1967, (32 FR 20865) making the baseline date September 1, 1967, or MY 1968. An estimated 12 percent of the fleet had head restraints in passenger cars by the baseline date of MY 1968, and are considered voluntary from MY 1968 to MY 2012. Since 100 percent of passenger cars had head restraints from MY 1969 to MY 2012, 88 percent of the passenger car costs are considered attributable from MY 1969 to MY 2012.

The NPRM for LTVs was published in the Federal Register on December 13, 1988, (53 FR 50047) making the baseline date September 1, 1988, or MY 1989. An estimated 58.2 percent of the fleet had head restraints in LTVs by the baseline date of MY 1989. All LTV head restraints up through MY 1989 are considered voluntary as are 58.2 percent from MY 1990 to MY 2012. LTV head restraint installation above that 58.2 percent baseline level are considered attributable from MY 1990 to MY 2012.

Vehicle manufacturers installed adjustable or nonadjustable (some people call them integral and others call them fixed, they are the same) head restraints in response to FMVSS No. 202. Adjustable head restraints can be added to bench as well as bucket seats. They can be shifted up and down through a finite range to suit the occupant, and some can also be rotated about their lateral axis to change the distance from the face of the restraint to the back of the occupant's head. Integral head restraints are built into a bucket seat, or in rare cases, a bench seat. They are not adjustable. Essentially the seat back is raised high enough to act as a head restraint, and seats with integral head restraints are commonly referred to as high-back seats. They require additional framing, padding, and seat covering as compared to a pre-standard seat back without a head restraint. Fixed head restraints are rigidly attached to the seat back, are not adjustable, and are typically composed of a metal frame that is covered with padding that allows the vehicle operator to see through the open areas of the framework.

The advantage of adjustable restraints is that they can potentially be optimally adjusted to more effectively capture the center of gravity of the head in a rear impact for a range of occupant sizes. Drivers may also use the adjustability to avoid perceived vision obstructions, when turning to the rear. The disadvantage is that taller occupants may neglect to adjust them up to an adequate height. Integral restraints avoid the problem of improper adjustment and sometimes cost less than adjustable restraints; however, historically they were criticized because, depending on their width, they might obstruct a driver's vision or create a wall that makes rear-seat passengers feel isolated from the people in front of them. Fixed see-through restraints try to avoid the shortcomings of the adjustable and the integral types. Fixed head restraints have similar bulk and costs as adjustable head restraints.

Head restraints are an addition to vehicles; therefore, a baseline was not used to determine the additional consumer cost and weight. The head restraint portion of the integral high-back seats was estimated by considering only the additional material and labor necessary to provide the increase in seat-back height necessary to meet the requirements for a head restraint. For the purposes of analysis, head restraints were divided into adjustable and nonadjustable categories. The nonadjustable restraints include integral and fixed head restraints.

Head restraint standard upgrade
FMVSS No. 202 was upgraded in a final rule issued on December 14, 2004, (69 FR 74848).[65] The upgrade, called FMVSS No. 202a, raised the outboard front seat's height requirement in the head restraint's highest position from 700 mm (27.5 inches) to 800 mm (31.5 inches) and added a new requirement that the restraint must be at least 750 mm (29.5 inches) high in its lowest position; also that the restraint should stay locked in position and cannot be lowered simply by pushing down on it in one action. That final rule also set a requirement limiting the distance between the back of the occupant's head and the occupant's head restraint (termed backset). After petitions for reconsideration, the final rule was amended.[66] The final rule requires a 55 mm backset limit, measured with the seat back at the manufacturer's designated seating position. The final rule also limits gaps between the head restraint and seat back, and requires a height retention lock test. The final rule is effective for all front seat passenger cars, LTVs, multipurpose passenger vehicles, and buses with a GVWR of 4,536 kg or 10,000 pounds or less.

The NPRM for passenger cars and LTVs was published in the Federal Register on January 4, 2001, (66 FR 968) making the baseline date September 1, 2000, or MY 2001. Since every vehicle had head restraints before the baseline date and the estimated costs of the upgrade are based on vehicles with head restraints, all of these additional costs starting in MY 2009 are attributable to the upgrade. The one exception is the locking mechanism, where we have data on baseline use of a locking mechanism and MY 2009 and later compliance, to be discussed later.

For rear outboard seats, the upgraded final rule applies to any voluntarily supplied rear head restraint, except school buses. A rear head restraint is defined as one that has a height greater than or equal to 700 mm. So, the standard does not require rear head restraints; however, if the seat back is 700 mm or more in height, then it is defined as a rear head restraint and must then have a minimum height of at least 750 mm and meet the backset requirements. Any adjustable rear head restraint would meet this height and also be required to meet the standard.

The effective dates of the requirements are:

- Front seat outboard: 80 percent of vehicles manufactured on or after September 1, 2009, and before September 1, 2010, must comply. One hundred percent of vehicles manufactured on or after September 1, 2010, must comply.
- Rear outboard seat: 80 percent of vehicles manufactured on or after September 1, 2010, and before September 1, 2011, must comply. One hundred percent of vehicles manufactured on or after September 1, 2011, must comply.

All cost for passenger car and LTV rear outboard seats and rear center seats are considered voluntary. Manufacturers are not required to provide any head restraints for the rear seat, even though with the head restraint upgrade a certain height is required if a head restraint is provided. Not all vehicles have head restraints in every rear seat that has a designated seating positions. This is particularly true for the rear center seats. The head restraints for the rear seats have been divided into two groups for ease of presentation and calculation. Tall head restraints that appear to be able to meet the upgraded height standard (although they are not required to) and short head restraints that are more typical of the designs available before the upgrade was considered.

[65] NHTSA Docket No. 2004-19807-002.
[66] NHTSA Docket No. 2007-27986-002, May 4, 2007, 72 FR 25484.

We chose these designations because the cost and weight impact depend on the size of the head restraints provided. We do have manufacturer compliance data with the upgrade requirements for MY 2010 to MY 2012. However, the upgrade requirements do not apply to the center rear seat, and many manufacturers did not provide any data on the center rear seat. Thus, we used Cars.com to examine the availability and size of rear center seat head restraints, by looking at photographs of cars for sale, to supplement data provided by the manufacturers, and to also examine MY 2009 head restraints. The manufacturers did provide certification information on MY 2009 head restraints, but since the upgrade wasn't effective yet, most of them just stated that they certified to meeting the original FMVSS No. 202, making that data not useful for determining the percentage of MY 2009 passenger cars and light trucks that met the upgraded standard. Designations of tall and short head restraints, that were not certified as compliant by the manufacturer are all subjective. We did not measure any head restraints.

There are cost and weight impacts associated with the original standard and with the upgrade. For passenger car and LTV front seat outboard head restraints, we have three cost and weight impacts to follow. This discussion will follow the outline below:
Passenger car and LTV front seat –

- percentage of vehicles by model year affected by the original standard,
- cost of the original standard FMVSS No. 202 weighted by adjustable/nonadjustable head restraints,
- weight of the original standard FMVSS No. 202 weighted by adjustable/nonadjustable head restraints,
- percentage of vehicles by model year affected by the upgrade in the standard in height,
- incremental cost of the upgrade in the standard in height,
- incremental weight of the upgrade in the standard in height,
- percentage of vehicles by model year affected by the locking mechanism requirement,
- the cost of the locking mechanism requirement, and
- no weight is attributable to the locking mechanism requirement.

Passenger car and LTV rear outboard seats and rear center seat –

- average number of rear outboard head restraints and rear center head restraints per vehicle by model year,
- the average number of small and tall head restraints per vehicle by model year
- cost of the small and tall rear head restraints weighted by adjustable/nonadjustable head restraints,
- weight of the small and tall head restraints weighted by adjustable/nonadjustable head restraints,
- percentage of vehicles by model year affected by the locking mechanism requirement,
- the cost of the locking mechanism requirement, and
- no weight is attributable to the locking mechanism requirement.

The learning curve will be applied to the original standard FMVSS No. 202 for the front outboard seats and to the voluntarily provided rear seat head restraints, but not to the upgrade in height or locking mechanism, since these were just starting to take effect in MY 2011.

Passenger Car Front Seat

Passenger Car Front Seat – Original Standard

An estimated 12 percent of MY 1968 passenger car front outboards seats had head restraints and 100 percent of MY 1969 and later had head restraints. The vast majority of American passenger cars were fitted with adjustable head restraints in every year 1968 to 2012. During the 1970s, nonadjustable head restraints reached their peak market share, averaging 31 percent. Starting in 1983, the percentage of nonadjustable head restraints started to drop dramatically. A sample of MY 1998 passenger cars representing 47 percent of passenger car sales found that 93 percent of head restraints were adjustable and only 7 percent were nonadjustable. An examination of Cars.com weighted by sales found that 97.54 percent of MY 2005 and 99.07 percent of MY 2010 passenger cars had adjustable head restraints. Table 202-1 shows the average percentage of nonadjustable and adjustable head restraints in the front seat of passenger cars from 1968 to 2012.

TABLE 202-1
AVERAGE DISTRIBUTION OF PERCENTAGE OF NONADJUSTABLE/ADJUSTABLE HEAD RESTRAINTS IN PASSENGER CARS FRONT SEAT FROM 1968 TO 2012

MODEL YEAR	% NONADJUSTABLE	% ADJUSTABLE
Front Seat		
1968-1981	31	69
1982-1997	13	87
1998-2002	7	93
2003-2007	2	98
2008-2012	1	99

Three separate studies of nonadjustable and adjustable headrests were conducted to determine the weight and consumer cost of the head restraint systems in MY 1969-1981 passenger cars.[67] [68] [69] There were a total of 8 nonadjustable (integral or fixed) head restraints in various model year passenger cars, 11 adjustable head restraints in MY 1969 passenger cars, and 5 adjustable head restraints in MY 1979-1981 passenger cars. The average model year of the nonadjustable and 1979-1981 adjustable head restraints was MY 1978. Table 202-2 shows the sales-weighted average weight and consumer cost per head restraint for passenger car front outboard seats in 2012 dollars.

[67] Harvey, M. R., Lesczhik, J. A., & McLean, R. F. (1979, November). *Cost evaluation for nine Federal Motor Vehicle Standards Volume IV, FMVSS 202 & 207* (Report No. DOT HS 805 318). Washington, DC: National Highway Traffic Safety Administration, Docket No. 2011-0066-0075.
[68] Gladstone, Harvey & Lesczhik, 1982, Docket No. 2011-0066-0066.
[69] Ibid.

TABLE 202-2 AVERAGE WEIGHT AND CONSUMER COST PER HEAD RESTRAINT IN PASSENGER CAR FRONT OUTBOARD SEATS			
CATEGORY	**MODEL YEAR**	**WEIGHT IN POUNDS**	**CONSUMER COST ($2012)**
Nonadjustable	1968-1981	3.09	$17.02
Adjustable	1969	4.97	$26.58
Adjustable	1979-1981	2.78	$19.38

Table 202-2 suggests that adjustable head restraints decreased significantly in weight and consumer cost between 1969 and 1979-1981. NHTSA believes the reductions are due to two factors:

- initial over design (extra wide and bulky restraints); and
- vehicle downsizing that resulted in smaller, narrower seats and elimination of full-bench seats.

Adjustable head restraints was one of the data sets used to determine the learning curve. When we used the change in price in the adjustable head restraints we found a progress rate of 0.91, which is a little lower than the average safety standard progress rate of 0.93 that we use for all safety standards for which we have not determined a specific progress rate.

To estimate the weight reduction, we assume that the average weight decreased at a linear rate from 1969 to 1981 and leveled off after that (since no further downsizing has occurred). Therefore, the average weight of passenger car head restraints attributable to the standard in any given model year is calculated using the following formulas.

1. Average Weight of Head Restraints (1969-1981) =

    a. For MY 1968 and 1969
    b. (% 1969-1981 Nonadjustable HR/100 * Weight of Nonadjustable HR) +
    c. (% 1969-1981 Adjustable HR/100 * Weight of 1969 Adjustable HR)
    d. For MY 1970 to 1980
    e. (% 1969-1981 Nonadjustable HR/100*Weight of Nonadjustable HR) +
        i. % 1969-1981 Adjustable HR/100*((Weight of 1979-81 Adjustable HR*(MY - 1969))/12 +
    f. (Weight of 1969 Adjustable HR*(1981-MY))/12))

    g. For MY 1981
    h. (% 1969-1981 Nonadjustable HR/100 * Weight of Nonadjustable HR) +
    i. (% 1969-1981 Adjustable HR/100 * Weight of 1979-1981 Adjustable HR)

2. Average Weight of Head Restraints (1982-2012) =
    (% 1982-2012 Nonadjustable HR/100 * Weight of Nonadjustable HR) +
    (% 1982-2012 Adjustable HR/100 * Weight of 1979-1981 Adjustable HR)

    For MY 1982 for MY 1997, the average weight increase is estimated to be 2.82 pounds. As the percentage of adjustable/nonadjustable head restraints changed, the average weight increase is estimated to be 2.80 pounds for MY 1998 to MY 2002, and then 2.78

> pounds from MY 2002 to MY 2012 (not counting the weight added for the head restraint upgrade that increased the weight for MY 2010 to MY 2012...

Table 202-6a shows the number of front outboard passenger car head restraints and Table 202-8 shows the resulting weights and costs by voluntary and attributable by model year.

Passenger Car Front Seat - Upgrade

Data was collected by NHTSA's Office of Compliance from the manufacturers for MYs 2010-2012 to examine the impact of the FMVSS No. 202 upgrade. The front seat head restraints of 92 percent of every passenger car sold in MY 2010 and 100 percent of the passenger cars sold in MY 2011 and MY 2012 were certified to meeting the upgraded height and backset requirements. Since the cost estimates for the upgrade are based on incremental costs over the head restraints that were already in the vehicle, we will assume that the increase all took place in MY 2010 and MY 2011 and we do not show any voluntary compliance for the upgrade in MY 2009 or prior years. We don't have measurements of baseline and post-standard head restraint height. We have assumed that the estimated average incremental height needed to meet the upgrade applies to all vehicles. In reality, some vehicles would have met the upgraded height requirements and others would have needed to add more than the average incremental height to meet the upgraded standard.

The consumer cost of the upgraded standard was estimated in the Final Regulatory Impact Analysis[70]. The average cost per inch of head restraint (excluding the adjustment hardware and assembly costs) was $2.04 (in 2012 dollars). The average cost per inch is important for the calculations, since we determined how much higher the head restraints needed to be to meet the upgraded requirements. Based on a sample of 14 MY 1999 vehicles, the average height that front outboard seat head restraints for passenger cars must be raised to meet the upgraded standard was 1.3 inches.[71] On a per head restraint basis, the cost is $2.04*1.3 inches = $2.65 per head restraint. On a per vehicle basis the cost is $2.65 * 2 head restraints = $5.30 per vehicle for MY 2011 and MY 2012. For MY 2010, 92 percent of the fleet complied, resulting in an average vehicle cost of $4.87 ($5.30 * .92).

The weight of the upgraded standard was determined using a similar methodology. A study of nine LTV head restraints was conducted to determine the weight and consumer cost of the head restraint systems in 1992-1994 make-model LTVs and vans.[72] Since head restraints are fairly similar between LTVs and passenger cars and this was the latest information available for weight and cost of head restraints, this information was used for both passenger cars and LTVs. The average integral seat weighed 0.38 pounds per inch and the average adjustable head restraints weighed 0.68 pounds per inch. Thus, the average passenger car front seat weight per inch was calculated to be 0.679 pounds for the MY 2010-2012 group (based on 99.07 percent of passenger

[70] NHTSA, *Final Regulatory Impact Analysis, FMVSS No. 202 Head Restraints for Passenger Vehicles*, November 2004, Docket No. 2004-19807-0001.
[71] This was an average of passenger cars and LTVs for front outboard seats, but the average passenger car and average LTV were so close to 1.3 inches that we used the same value for both.
[72] Fladmark, G. L & Khadilkar, A. V. (1994). Cost Estimates of Head Restraints in LTVs/Vans, Volume I (Report No. DOT HS 809 796), Washington, DC: National Highway Traffic Safety Administration, Docket No. 2011-0066-0026.

car front seat head restraints being adjustable head restraints and 0.93 percent being integral head restraints). Given that the average passenger car front seat head restraint needed to be increased by 1.3 inches, the incremental weight for MY 2011-2012 is estimated to be increased by 0.679 pounds*1.3 inches = 0.88 pounds. On a passenger car basis, the upgrade added 0.88 pounds *2 head restraints = 1.77 pounds. The MY 2010 incremental weight was 1.62 pounds, taking into account that 92 percent of the fleet complied in MY 2010 (1.77*0.92).

There was also a cost to add locking mechanisms to those adjustable head restraints that don't have locking mechanisms. These are simple devices for height adjustment that were estimated to cost about $0.20 per head restraint. Based on the survey of 14 MY 1999 vehicles, half of the adjustable head restraints had locking mechanisms. This would be voluntary compliance. Since the baseline head restraint teardown vehicles were MY 1978 vintage and probably did not have a locking mechanism, we added $0.10 per head restraint for MY 1999 and later to the voluntary costs of head restraints to account for the 50 percent voluntary compliance.

Since 99.07 percent of the MY 2008-2012 passenger car fleet had adjustable head restraints in the front seat, we can determine the costs of the locking mechanism for MY 2010-2012.

Front seat = $0.20*.9907*2 = $.40 per vehicle minus $0.20*.9907*0.5 voluntary compliance *2 = $.20 per vehicle results in a net increase in cost of $0.20 that is attributable to the front seat upgrade for the locking mechanism for two seats.

Thus, the total average cost for passenger car front seat head restraint upgrade for two seats attributable for MY 2010 is $5.05 (0.92 * $5.30 + 0.92 * 0.9907 * $0.20*2 - $0.20 voluntary compliance) and $5.50 for MY 2011 and MY 2012 ($5.30 + $0.20), before applying the learning curve.

Passenger Car Rear Seat

Neither the original standard nor the upgrade requires manufacturers to supply rear seat head restraints. Approximately 41 percent of the MY 1999 vehicles had head restraints in the outboard rear seats. These are all voluntary. This 41 percent estimate was for both passenger cars and LTVs and will be applied to both. NHTSA has not attempted to assemble an estimate of the percentage of the fleet with rear head restraints that were voluntarily supplied in passenger cars by model year with the exception of the data we collected for MY 2005 and from MY 2009-2012, where all passenger cars with rear seats had rear outboard head restraints. For this analysis we are assuming a gradual build-up of rear outboard head restraints starting at 5 percent in 1992 and increasing 5 percentage points per year to 41 percent for MY 1999 and then increasing more quickly to the 97 percent found for MY 2005 (see Table 202-6b). The percentage of passenger car 2-seaters that don't have a rear seat fluctuates from year to year between 1 and 3 percent of total passenger car sales.

Based on the MY 2005 examination of Cars.com and weighting that data by MY 2005 Polk data, we estimated 42.43 percent of the passenger car rear seat head restraints were nonadjustable and 57.57 percent were adjustable. For MY 2005 there were on average 1.97 rear head restraints per passenger car, with 2-seaters not having a rear head restraint and most center rear seats not having a head restraint.

By 2010 there was a big change in the distribution of adjustable versus nonadjustable head restraints in the rear seat of passenger cars and the percentage of passenger cars providing a head restraint for the rear center seat. Based on the MY 2010 examination of Cars.com and weighting that data by MY 2010 Polk data, we estimate that 18.57 percent of the passenger car rear seat head restraints were nonadjustable and 81.43 percent were adjustable. For MY 2009 to MY 2012 there were on average 2.74 rear seat head restraints per passenger car, with 2-seaters not having a rear head restraint, but 76 percent of passenger cars providing a head restraint in the rear center seat.

For ease of calculation we have split the rear head restraints into outboard seats and center seats, adjustable and nonadjustable, and short and tall head restraints. The average cost for short rear seat head restraints is taken from the front seat head restraints Table 202-2, but we applied the rear seat distribution of adjustable and nonadjustable head restraints. The average cost for tall rear seat head restraints is assumed to be the sum of the original standard front seat costs and the upgraded costs from front head restraints. In addition we applied the learning curve to costs. Table 202-9 summarizes the results for the rear seat of passenger cars.

Data was collected by NHTSA's Office of Compliance from the manufacturers for MYs 2010-2012 to examine the impact of the FMVSS No. 202 upgrade. Data on the rear seat of every passenger car expected to be sold in MY 2010 to 2012 was provided and combined into Table 202-3. In addition, we used Cars.com to examine the availability and size of rear center seat head restraints, by looking at photographs of cars for sale, to supplement data provided by the manufacturers, and to also examine MY 2009 head restraints. The important conclusions that can be drawn from this table are:

- Every passenger car with rear seats had outboard rear head restraints of some type. In MY 2009, small outboard head restraints were in 36.9 percent of the fleet (numbering 0.738 head restraints per average vehicle divided by 2 to get the percentage of the fleet). By MY 2012, small outboard head restraints were almost completely replaced by tall outboard head restraints (.036 divided by 2 means that small outboard rear head restraints were in only 1.8 percent of MY 2012 passenger car fleet).
- About 91 percent of passenger cars have a rear center seat. The number of small center head restraints stayed about the same from MY 2009 to MY 2012, possibly because the upgraded head restraint standard doesn't apply to the center seats. Between MY 2009 and MY 2012 the number of center seats without a head restraint declined.
- The average number of rear outboard seats per LTV is higher than 2.0. Several LTVs have a second and third row, while regular cab pickups and most cargo vans have no rear seat. As with passenger cars, the number of small outboard head restraints reduced dramatically between MY 2009 and MY 2012, probably as a result of the upgraded head restraint standard.

- The number of rear center seats in LTVs is similar to the number in passenger cars, but the number of vehicles with no head restraints in the rear center seat is higher than the number in passenger cars. In general, pickup trucks make up the majority of the vehicles that might not supply a head restraint for the rear center seat that has a designated seating position.

Table 202-3 Rear Seat Head Restraints for MY 2009-2012 Average Number of Seating Positions and Head Restraints per Vehicle							
Passenger Cars	**Rear Outboard Seats**	**Small Outboard Head Restraints**	**Tall Outboard Head Restraints**	**Rear Center Seats**	**Small Center Head Restraints**	**Tall Center Head Restraints**	**No Center Rear Head Restraints**
MY 2009	1.997	0.738	1.259	0.938	0.419	0.290	0.230
MY 2010	1.971	0.657	1.314	0.910	0.405	0.303	0.202
MY 2011	1.969	0.282	1.687	0.915	0.548	0.298	0.069
MY 2012	1.983	0.036	1.948	0.909	0.443	0.329	0.137
LTVs							
MY 2009	2.413	0.744	1.669	0.946	0.310	0.231	0.404
MY 2010	2.269	0.474	1.795	0.927	0.281	0.229	0.417
MY 2011	2.284	0.252	2.031	0.945	0.295	0.303	0.348
MY 2012	2.131	0.016	2.115	0.873	0.370	0.303	0.199

The consumer cost of the upgraded standard was estimated in the Final Regulatory Impact Analysis.[73] The average cost of a head restraint was $19.45 and the average cost per inch of head restraint was $2.04 (in 2012 dollars). Based on a sample of 14 MY 1999 vehicles, the average height that rear outboard seat head restraints for passenger cars must be raised to meet the upgraded standard was 1.25 inches. On average, the cost is $2.04*1.25 inches = $2.55 per seating position.

The resulting costs for MY 2009 to MY 2012, after weighting the costs for adjustable and nonadjustable head restraints, are $18.94 for a small head restraint and $21.48 for a tall head restraint. These cost figures are then weighted by the percentage of small versus tall rear head restraints, multiplied by the average number of rear head restraints per passenger car, costs for locking mechanisms are added and then the learning factors are applied.

There was also a cost to add locking mechanisms to those adjustable head restraints that don't have locking mechanisms. These are simple devices for height adjustment that were estimated to cost about $0.20 per head restraint. Based on the survey of 14 MY 1999 vehicles, half of the adjustable head restraints had locking mechanisms. Based on our analysis of Cars.com, 81.43

[73] NHTSA, *Final Regulatory Impact Analysis, FMVSS No. 202 Head Restraints for Passenger Vehicles,* November 2004, Docket No. 2004-19807-0001.

percent of the MY 2010 passenger cars with head restraints in the rear seat had adjustable head restraints, we can determine the costs of the locking mechanism. An example calculation for MY 2010, for which we assume all adjustable head restraints have a locking mechanism is

MY 2010 rear seat = $0.20 per locking mechanism *2.881 rear seats *.8143 adjustable head restraints = $0.46 per average passenger car.

The weight for a small head restraint for passenger car rear seats was based on the front outboard seat head restraints before the upgrade. We assume the same basic weight of 2.78 pounds per adjustable head restraints and 3.09 pounds per nonadjustable head restraints and then weight those estimates by the passenger car rear seat head restraint distribution for the appropriate time period of 57.57 percent adjustable and 42.43 percent nonadjustable for MY 1992 to MY 2007 and 81.43 percent adjustable and 18.57 percent nonadjustable for MY 2008-2012. Thus, for example, a small rear head restraint for MY 2008-2012 was estimated to weigh 2.83 pounds.

The weight for a tall head restraint for passenger car rear seats was determined using a similar methodology as used for the front seat upgrade. The average integral seat weighed 0.38 pounds per inch and the average adjustable head restraints weighed 0.68 pounds per inch. Thus, the average passenger car rear seat weight per inch was calculated to be 0.62 pounds per inch (based on 81.43 percent of passenger car rear seat head restraints being adjustable head restraints and 18.57 percent being integral head restraints). Given that the average passenger car rear seat head restraint needed to be increased by 1.25 inches, the weight for per tall head restraint is estimated to be 2.83 pounds + 0.62*1.25 = 3.61 pounds. In addition, we consider the average number of rear seat head restraints and the distribution between tall and short head restraints. From Table 202-3, the percentage of the passenger car rear head restraints that were small outboard, tall outboard, small center and tall center were weighted by the number of outboard and center seats to determine by year what percentage of the total rear seats were small and tall. For MY 2009, 43 percent of the rear passenger car seats were small; for MY 2010, 39.7 percent were small; for MY 2011, 29 percent were small; and for MY 2012, 17 percent were small. Thus, an example calculation for MY 2010 passenger car rear head restraints is:

MY 2010 = The 39.7 percent small and 60.3 percent tall are weighted by the 2.83 pounds for small and 3.61 pounds for tall and average 3.30 pounds. 3.30 pounds*2.68 rear head restraints per average passenger car = 8.84 pounds.

The results are shown in Table 202-9.

LTV Front Seat

Head restraints have been required since September 1, 1991, (MY 1992) in pickup trucks, vans, and SUVs with a GVWR of 10,000 pounds or less. Nevertheless, head restraints or other devices capable of meeting FMVSS No. 202 (e.g., high-backed captain's chairs) were already installed in most vans, SUVs, and some pickup trucks well before 1992, even before the rulemaking process that extended the standard to LTVs.

Table 202-4 shows the average percentage of nonadjustable and adjustable LTV head restraints between 1992 and 2012. In a sample of MY 1998 LTVs representing 72 percent of LTV sales, a sales weighted distribution found 80 percent nonadjustable and 20 percent adjustable. These percentages changed dramatically. An examination of Cars.com weighted by sales found that 78.38 percent of MY 2005 and 94.04 percent of MY 2010 LTVs had adjustable head restraints.

TABLE 202-4
AVERAGE PERCENTAGE OF NONADJUSTABLE/ADJUSTABLE HEAD RESTRAINTS IN LTVS FRONT SEAT FROM 1992 TO 2012

MODEL YEAR	% NONADJUSTABLE	% ADJUSTABLE
1992-1997	55	45
1998-2002	80	20
2003-2007	21.62	78.38
2008-2012	5.96	94.04

A study of nine LTV head restraints was conducted to determine the weight and consumer cost of the head restraint systems in 1992-1994 make-model LTVs and vans.[74] Four of the head restraints were nonadjustable while five were adjustable. Table 202-5 shows the basic data from the cost teardown contract. Table 202-6a shows the number of front outboard LTV head restraints and Table 202-10 shows the resulting weights and costs by voluntary and attributable by model year.

TABLE 202-5
AVERAGE WEIGHT AND CONSUMER COST PER HEAD RESTRAINT IN LTVS FRONT SEAT

CATEGORY	WEIGHT IN POUNDS	CONSUMER COST ($2012)
Nonadjustable	3.72	$18.41
Adjustable	4.69	$19.97

LTV Front Seat - Upgrade

Data was collected by NHTSA’s Office of Compliance from the manufacturers for MYs 2010-2012 to examine the impact of the FMVSS No. 202 upgrade. The front seat head restraints of 92 percent of every LTV sold in MY 2010 and 100 percent of the LTVs sold in MY 2011 and MY 2012 were certified to meeting the upgraded height and backset requirements. Data on the rear seat of every LTV expected to be sold in MY 2010 to 2012 was provided and combined into Table 202-3. In addition, we used Cars.com to examine the availability and size of rear center seat head restraints, by looking at photographs of LTVs for sale, to supplement data provided by the manufacturers, and to also examine MY 2009 head restraints. Since the cost estimates for the upgrade are based on incremental costs over the head restraints that were already in the vehicle, we will assume that the increase all took place in MY 2010 and MY 2011 and we do not show any voluntary compliance for the upgrade in MY 2009 or prior years.

[74] Fladmark & Khadilkar, DOT HS 809 796, 1994, Docket No. 2011-0066-0026.

The consumer cost of the upgraded standard was estimated in the Final Regulatory Impact Analysis.[75] The average cost of a head restraint was $19.45 and the average cost per inch of head restraint was $2.04 (in 2012 dollars). The average cost per inch is important for the calculations, since we determined how much higher the head restraints needed to be to meet the upgraded requirements. Based on a sample of 14 MY 1999 vehicles, the average height that front outboard seat head restraints for LTVs must be raised to meet the upgraded standard was 1.3 inches. On a per head restraint basis, the cost is $2.04 * 1.3 inches = $2.65 per LTV front seat head restraint. On a per vehicle basis the cost is $2.65 * 2 head restraints = $5.30 per vehicle for MY 2011 and MY 2012. For MY 2010, 92.3 percent of the fleet complied, resulting in an average vehicle cost of $4.89 ($5.30 * .923).

The weight of the upgraded standard was determined using a similar methodology. A study of nine LTV head restraints was conducted to determine the weight and consumer cost of the head restraint systems in 1992-1994 make-model LTVs and vans.[76] The average integral seat weighed 0.38 pounds per inch and the average adjustable head restraints weighed 0.68 pounds per inch. Thus, the average LTV front seat weight per inch for the upgrade was calculated to be 0.66 pounds per inch (based on the 2008-2012 distribution of 94.04 percent of LTV front seat head restraints being adjustable head restraints and 5.96 percent being integral head restraints). Given that the average LTV front seat head restraint needed to be increased by 1.3 inches, the incremental weight for MY 2011-2012 per head restraint is estimated to be 0.66 pounds*1.3 inches = 0.86 pounds.

There was also a cost to add locking mechanisms to those adjustable head restraints that don't have locking mechanisms. These are simple devices for height adjustment that were estimated to cost about $0.20 per head restraint. Based on the survey of 14 MY 1999 vehicles, half of the adjustable head restraints had locking mechanisms. This would be voluntary compliance. With 94.04 percent of the fleet having adjustable head restraints in the front seat, we can determine the costs of the locking mechanism for MY 2009-2012.

Front seat = $0.20*.9404*0.5 voluntary compliance = $0.09 per vehicle.

Since the baseline head restraint teardown vehicles were MY 1992-1994 vintage and probably did not have a locking mechanism, we added $0.09 per vehicle for MY 1999 to MY 2012 to the voluntary costs of head restraints to account for the 50 percent voluntary compliance.

Since 94.04 percent of the MY 2008-2012 LTV fleet had adjustable head restraints in the front seat, we can determine the costs of the locking mechanism for MY 2010-2012.

Front seat = $0.20*.9404 = $.19 per head restraint minus voluntary compliance of $0.09 per head restraint results in a net increase in cost of $0.10 per head restraint that is attributable to the front seat upgrade for the locking mechanism.

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[75] NHTSA, *Final Regulatory Impact Analysis, FMVSS No. 202 Head Restraints for Passenger Vehicles*, November 2004, Docket No. 2004-19807-0001.
[76] Fladmark & Khadilkar, DOT HS 809 796, 1994, Docket No. 2011-0066-0026.

Thus, the total average cost for LTVs front seat head restraint upgrade for two seats attributable for MY 2010 is $5.05 (0.923 * $5.30 + 0.9404 * 0.9907 * $0.20 * 2 minus voluntary compliance $0.18) and $5.49 for MY 2011 and MY 2012 ($5.30 + $0.19), before applying the learning curve.

LTV Rear Seat

Head restraints have never been required in the rear seat of LTVs. Some have voluntarily been supplied as integral restraints in captain's chairs (which may be optional equipment) or as adjustable head restraints. In the Final Regulatory Impact Analysis,[77] 41 percent of the MY 1999 vehicles were estimated to be equipped with rear head restraints. This estimate was for both passenger cars and LTVs and will be applied to both. NHTSA has not attempted to assemble an estimate of the percentage of the fleet with rear head restraints that were voluntarily supplied in LTVs by model year with the exception of MY 2005 and the data collected for MY 2009-2012. For this analysis we are assuming a gradual build-up of rear outboard head restraints starting at 5 percent in 1992 and increasing 5 percentage points per year to 41 percent for MY 1999 and then increasing more quickly to the 100 percent of those vehicles with an outboard seating position found for MY 2005 (see Table 202-6c). The percentage of LTVs with center rear head restraints was estimated to be 55 percent of the percentage of LTV rear outboard head restraints.

Based on the MY 2005 examination of Cars.com and weighting that data by MY 2005 Polk data, we estimated 11.64 percent of the LTV rear seat head restraints were nonadjustable and 88.36 percent were adjustable. For MY 2005 there were on average 2.34 head restraints per LTV. This is a weighted average that is the result of many different factors. For example, there are no seats (and thus no head restraints) in the rear of regular pickups or cargo vans (which comprised 8 percent of the LTV fleet in MY 2009); however, there are several SUVs and vans having rear head restraints for the outboard seats and center seats of the second and third row. The MY 2005 data will be used from MY 1992 to MY 2007.

Based on the MY 2010 examination of Cars.com and weighting that data by MY 2010 Polk data, we estimate that 17.71 percent of the LTV rear seat head restraints were nonadjustable and 82.29 percent were adjustable. For MY 2010 there were on average 2.8 rear head restraints per LTV with many more vehicles providing head restraints in the rear seats. The MY 2010 distribution of nonadjustable/adjustable head restraints will be used from MY 2008 to MY 2012.

We have split the rear head restraints into outboard seats and center seats, adjustable and nonadjustable, and short and tall head restraints. The average cost for a short rear seat head restraint is taken from the front seat head restraints for LTVs in Table 202-5 ($18.41 for nonadjustable and $19.97 for adjustable head restraints).

The consumer cost of the upgraded standard was estimated in the Final Regulatory Impact Analysis.[78] The average cost of a head restraint was $19.45 and the average cost per inch of head

[77] NHTSA, *Final Regulatory Impact Analysis, FMVSS No. 202 Head Restraints for Passenger Vehicles*, November 2004, Docket No. 2004-19807-0001.
[78] NHTSA, *Final Regulatory Impact Analysis, FMVSS No. 202 Head Restraints for Passenger Vehicles*, November 2004, Docket No. 2004-19807-0001.

restraint was $2.04 (in 2012 dollars). Based on a sample of 14 MY 1999 vehicles, the average height that rear outboard seat head restraints for LTVs would have to be raised to meet the upgraded standard was 1.25 inches. On a per vehicle basis, the cost is $2.04*1.25 inches = $2.55 per seating position.

The average cost for tall rear seat head restraints is assumed to be the sum of the original standard front seat costs and the upgraded costs from front head restraints ($2.55), resulting in the costs for tall LTV rear head restraints of $20.96 ($18.41 + $2.55) for nonadjustable and $22.52 ($19.97 + $2.55) for adjustable. These cost figures are then weighted by the percentage of small versus tall rear head restraints, the percentage of adjustable and nonadjustable, multiplied by the average number of rear head restraints per LTV, costs for locking mechanisms are added and then the learning factors are applied. Table 202-11 summarizes the results for the rear seat head restraints of LTVs.

There was also a cost to add locking mechanisms to those head restraints that don't have locking mechanisms. These are simple devices for height adjustment that were estimated to cost about $0.20 per head restraint. Based on the survey of 14 MY 1999 vehicles, half of the adjustable head restraints had locking mechanisms. Based on our analysis of Cars.com, 82.29 percent of the MY 2010 LTVs with head restraints in the rear seat had adjustable head restraints, we can determine the incremental costs of the locking mechanism.

For example on a vehicle basis:
MY 2012 LTV outboard and center rear seats combined = $0.20*2.80 head restraints*.8229 adjustable = $0.46.

The weight of the voluntary compliance with the basic standard for LTV rear seats was determined using a similar methodology as used for the rear seat in passenger cars. We assume the same basic weight of 4.69 pounds for a small adjustable head restraint and 3.72 pounds for a small nonadjustable head restraint and then weight those estimates by the LTV rear seat head restraint distribution for the appropriate time period of 88.36 percent adjustable and 11.64 percent nonadjustable for MY 1999 to MY 2007 and 82.29 percent adjustable and 17.71 percent nonadjustable for MY 2008-2012. The estimated weight for a tall head restraint, to take into account the impact of the upgrade is 0.38 pounds for nonadjustable head restraints and 0.68 pounds for adjustable head restraints higher than the basic weight. In addition, there is an adjustment to account for more than 2 head restraints in the rear seat.

In recent years, dynamic or active head restraints (that move closer to the head when a crash occurs are being certified as complying in MY 2012), and electric or power head restraints (that automatically move closer to the head after starting the vehicle are being certified as complying, starting in MY 2010) have been introduced in a small number of vehicles. NHTSA has done no cost teardown studies of these newer systems and has not included them as voluntary costs in this analysis.

Table 202-6a, 202-6b, and 202-6c provides the number of head restraints per vehicle, since the rear seats can have more than 2 per vehicle for passenger cars and LTVs for the front seat and rear seat. Tables 202-7a and 202-7b provide cost factors and cost estimates for the rear seats of passenger cars and LTVs, respectively. An example calculation for MY 2012 from Table 202-7a is: .174 small * $18.94 = $3.29, .826 tall * $21.48 = $17.75; $3.29 + $17.75 = $21.04 for 1 head restraint. $21.04 * 2.755 head restraints = $57.97; $57.97 + $0.47 for the locking mechanism = $58.44.

Table 202-8, Table 202-9, Table 202-10, and Table 202-11 provide the estimated passenger car and LTV head restraint results combining the original standard, the upgraded standard, voluntary, and attributable compliance.

Table 202-6a
Front Seat Head Restraints
Passenger Cars and LTVs

Model Year	Front Outboard Passenger Cars			Front Outboard LTVS		
	Number of Front Seating Positions	Percent With Head Restraints	Number of Head Restraints	Number of Front Seating Positions	Percent With Head Restraints	Number of Head Restraints
1968	2	12	0.24	2	10.34	0.21
1969	2	100	2.00	2	10.34	0.21
1970	2	100	2.00	2	10.34	0.21
1971	2	100	2.00	2	10.34	0.21
1972	2	100	2.00	2	10.34	0.21
1973	2	100	2.00	2	10.34	0.21
1974	2	100	2.00	2	24.07	0.48
1975	2	100	2.00	2	24.07	0.48
1976	2	100	2.00	2	24.07	0.48
1977	2	100	2.00	2	24.07	0.48
1978	2	100	2.00	2	24.07	0.48
1979	2	100	2.00	2	24.07	0.48
1980	2	100	2.00	2	24.07	0.48
1981	2	100	2.00	2	24.07	0.48
1982	2	100	2.00	2	24.07	0.48
1983	2	100	2.00	2	40.77	0.82
1984	2	100	2.00	2	47.24	0.94
1985	2	100	2.00	2	53.77	1.08
1986	2	100	2.00	2	55.26	1.11
1987	2	100	2.00	2	64.28	1.29
1988	2	100	2.00	2	60.87	1.22
1989	2	100	2.00	2	58.2	1.16
1990	2	100	2.00	2	69.44	1.39
1991	2	100	2.00	2	70.51	1.41

1992	2	100	2.00	2	100	2.00
1993	2	100	2.00	2	100	2.00
1994	2	100	2.00	2	100	2.00
1995	2	100	2.00	2	100	2.00
1996	2	100	2.00	2	100	2.00
1997	2	100	2.00	2	100	2.00
1998	2	100	2.00	2	100	2.00
1999	2	100	2.00	2	100	2.00
2000	2	100	2.00	2	100	2.00
2001	2	100	2.00	2	100	2.00
2002	2	100	2.00	2	100	2.00
2003	2	100	2.00	2	100	2.00
2004	2	100	2.00	2	100	2.00
2005	2	100	2.00	2	100	2.00
2006	2	100	2.00	2	100	2.00
2007	2	100	2.00	2	100	2.00
2008	2	100	2.00	2	100	2.00
2009	2	100	2.00	2	100	2.00
2010	2	100	2.00	2	100	2.00
2011	2	100	2.00	2	100	2.00
2012	2	100	2.00	2	100	2.00

Table 202-6b						
Passenger Car Rear Seat Head Restraints						
Model Year	**Rear Outboard Passenger Cars**			**Rear Center Passenger Cars**		
	Number of Rear Seating Positions	**Percent With Head Restraints**	**Number of Head Restraints**	**Number of Rear Seating Positions**	**Percent With Head Restraints**	**Number of Head Restraints**
1968	1.98	0	0.00	0.62	0	0.00
1969	1.98	0	0.00	0.62	0	0.00
1970	1.98	0	0.00	0.62	0	0.00
1971	1.98	0	0.00	0.62	0	0.00
1972	1.98	0	0.00	0.62	0	0.00
1973	1.98	0	0.00	0.62	0	0.00
1974	1.98	0	0.00	0.62	0	0.00
1975	1.98	0	0.00	0.62	0	0.00
1976	1.98	0	0.00	0.62	0	0.00
1977	1.96	0	0.00	0.62	0	0.00
1978	1.96	0	0.00	0.62	0	0.00
1979	1.96	0	0.00	0.62	0	0.00
1980	1.96	0	0.00	0.62	0	0.00
1981	1.96	0	0.00	0.62	0	0.00
1982	1.96	0	0.00	0.62	0	0.00
1983	1.96	0	0.00	0.62	0	0.00
1984	1.96	0	0.00	0.62	0	0.00
1985	1.96	0	0.00	0.62	0	0.00
1986	1.96	0	0.00	0.62	0	0.00
1987	1.97	0	0.00	0.86	0	0.00
1988	1.97	0	0.00	0.86	0	0.00
1989	1.97	0	0.00	0.86	0	0.00
1990	1.96	0	0.00	0.86	0	0.00
1991	1.96	0	0.00	0.86	0	0.00
1992	1.96	5	0.10	0.86	3.9	0.03
1993	1.96	10	0.20	0.86	7.7	0.07
1994	1.96	15	0.29	0.86	11.6	0.10
1995	1.97	20	0.39	0.90	15.4	0.14
1996	1.97	25	0.49	0.90	19.3	0.17
1997	1.97	30	0.59	0.90	23.1	0.21
1998	1.97	35	0.69	0.90	27.0	0.24
1999	1.97	41	0.81	0.90	31.6	0.28
2000	1.97	50	0.99	0.90	38.5	0.35

2001	1.97	60	1.18	0.90	46.2	0.42
2002	1.97	70	1.38	0.90	53.9	0.49
2003	1.96	80	1.57	0.92	61.6	0.57
2004	1.96	90	1.76	0.92	69.3	0.64
2005	1.96	100	1.96	0.92	77.0	0.71
2006	1.96	100	1.96	0.92	77.0	0.71
2007	1.96	100	1.96	0.92	77.0	0.71
2008	1.99	100	1.99	0.93	77.0	0.71
2009	1.99	100	1.99	0.94	75.5	0.71
2010	1.97	100	1.97	0.91	77.8	0.71
2011	1.97	100	1.97	0.91	92.4	0.85
2012	1.98	100	1.98	0.91	84.9	0.77

Table 202-6c

LTV Rear Seat Head Restraints

Model Year	Rear Outboard LTVs			Rear Center LTVs		
	Number of Rear Seating Positions	Percent With Head Restraints	Number of Head Restraints	Number of Rear Seating Positions	Percent With Head Restraints	Number of Head Restraints
1968	0.39	0	0.00	0.09	0	0.00
1969	0.39	0	0.00	0.09	0	0.00
1970	0.39	0	0.00	0.09	0	0.00
1971	0.39	0	0.00	0.09	0	0.00
1972	0.39	0	0.00	0.09	0	0.00
1973	0.39	0	0.00	0.09	0	0.00
1974	0.39	0	0.00	0.09	0	0.00
1975	0.39	0	0.00	0.09	0	0.00
1976	0.39	0	0.00	0.09	0	0.00
1977	0.83	0	0.00	0.14	0	0.00
1978	0.83	0	0.00	0.14	0	0.00
1979	0.83	0	0.00	0.14	0	0.00
1980	0.83	0	0.00	0.14	0	0.00
1981	0.83	0	0.00	0.14	0	0.00
1982	0.83	0	0.00	0.14	0	0.00
1983	0.83	0	0.00	0.14	0	0.00
1984	0.83	0	0.00	0.14	0	0.00
1985	0.83	0	0.00	0.14	0	0.00
1986	0.83	0	0.00	0.14	0	0.00
1987	1.31	0	0.00	0.26	0	0.00

1988	1.31	0	0.00	0.26	0	0.00
1989	1.31	0	0.00	0.26	0	0.00
1990	1.31	0	0.00	0.26	0	0.00
1991	1.31	0	0.00	0.26	0	0.00
1992	1.31	5	0.07	0.26	2.8	0.01
1993	1.31	10	0.13	0.26	5.5	0.01
1994	1.31	15	0.20	0.26	8.3	0.02
1995	2.21	20	0.44	0.70	11.0	0.08
1996	2.21	25	0.55	0.70	13.8	0.10
1997	2.21	30	0.66	0.70	16.5	0.12
1998	2.21	35	0.77	0.70	19.3	0.13
1999	2.21	41	0.91	0.70	22.6	0.16
2000	2.21	50	1.11	0.70	27.5	0.19
2001	2.21	60	1.33	0.70	33.0	0.23
2002	2.21	70	1.55	0.70	38.5	0.27
2003	2.32	80	1.86	0.94	44.0	0.41
2004	2.32	90	2.09	0.94	49.5	0.46
2005	2.32	100	2.32	0.94	55.0	0.52
2006	2.32	100	2.32	0.94	55.0	0.52
2007	2.32	100	2.32	0.94	55.0	0.52
2008	2.34	100	2.34	0.97	55.0	0.53
2009	2.41	100	2.41	0.95	57.3	0.54
2010	2.27	100	2.27	0.93	55.0	0.51
2011	2.28	100	2.28	0.95	63.2	0.60
2012	2.13	100	2.13	0.87	77.2	0.67

Table 202-7a								
Passenger Car Rear Seat Costing Factors and Cost Estimates								
Model Year	**Percent Small**	**Percent Tall**	**Cost Small**	**Cost Tall**	**Rear Head Restraints per car**	**Locking Mechanism**	**Cost Before Learning**	**Cost After Learning**
1992	100	0	$18.64	$21.19	0.13	$0.00	$2.44	$2.44
1993	100	0	$18.64	$21.19	0.26	$0.00	$4.89	$4.86
1994	100	0	$18.64	$21.19	0.39	$0.00	$7.32	$7.22
1995	100	0	$18.64	$21.19	0.53	$0.00	$9.93	$9.73
1996	100	0	$18.64	$21.19	0.67	$0.00	$12.41	$12.09
1997	100	0	$18.64	$21.19	0.80	$0.00	$14.90	$14.42
1998	100	0	$18.38	$20.92	0.93	$0.00	$17.13	$16.48
1999	100	0	$18.38	$20.92	1.09	$0.06	$20.13	$19.24
2000	100	0	$18.38	$20.92	1.33	$0.08	$24.54	$23.33
2001	100	0	$18.38	$20.92	1.60	$0.09	$29.45	$27.83
2002	100	0	$18.38	$20.92	1.86	$0.11	$34.36	$32.29
2003	91.0	9.0	$18.38	$20.92	2.13	$0.12	$39.83	$37.24
2004	82.0	18.0	$18.38	$20.92	2.40	$0.14	$45.36	$42.20
2005	73.0	27.0	$18.38	$20.92	2.67	$0.15	$51.01	$47.22
2006	64.0	36.0	$18.38	$20.92	2.67	$0.15	$51.62	$47.57
2007	55.0	45.0	$18.38	$20.92	2.67	$0.15	$52.23	$47.92
2008	46.0	54.0	$18.94	$21.48	2.70	$0.22	$55.05	$50.34
2009	42.8	57.2	$18.94	$21.48	2.70	$0.22	$55.26	$50.40
2010	39.7	60.3	$18.94	$21.48	2.68	$0.43	$55.26	$50.28
2011	29.5	70.5	$18.94	$21.48	2.81	$0.46	$58.82	$53.35
2012	17.4	82.6	$18.94	$21.48	2.76	$0.47	$58.44	$52.82

Table 202-7b								
LTV Rear Seat Costing Factors and Cost Estimates								
Model Year	**Percent Small**	**Percent Tall**	**Cost Small**	**Cost Tall**	**Rear Head Restraints per car**	**Locking Mechanism**	**Cost Before Learning**	**Cost After Learning**
1992	100	0	$19.79	$22.34	0.07	$0.00	$1.44	$1.44
1993	100	0	$19.79	$22.34	0.15	$0.00	$2.88	$2.86
1994	100	0	$19.79	$22.34	0.22	$0.00	$4.31	$4.25
1995	100	0	$19.79	$22.34	0.52	$0.00	$10.27	$10.06
1996	100	0	$19.79	$22.34	0.65	$0.00	$12.83	$12.49
1997	100	0	$19.79	$22.34	0.78	$0.00	$15.40	$14.90
1998	100	0	$19.79	$22.34	0.91	$0.00	$17.97	$17.28
1999	100	0	$19.79	$22.34	1.06	$0.09	$21.14	$20.21
2000	100	0	$19.79	$22.34	1.30	$0.11	$25.78	$24.50
2001	100	0	$19.79	$22.34	1.56	$0.14	$30.93	$29.23
2002	100	0	$19.79	$22.34	1.82	$0.16	$36.09	$33.92
2003	91.0	9.0	$19.79	$22.34	2.27	$0.20	$45.62	$42.66
2004	82.0	18.0	$19.79	$22.34	2.55	$0.23	$51.91	$48.30
2005	73.0	27.0	$19.79	$22.34	2.84	$0.25	$58.33	$54.00
2006	64.0	36.0	$19.79	$22.34	2.84	$0.25	$58.98	$54.36
2007	55.0	45.0	$19.79	$22.34	2.84	$0.25	$59.63	$54.72
2008	46.0	54.0	$19.70	$22.24	2.87	$0.24	$60.74	$55.55
2009	35.7	64.3	$19.70	$22.24	2.95	$0.24	$63.28	$57.71
2010	27.2	72.8	$19.70	$22.24	2.78	$0.46	$60.33	$54.89
2011	19.0	81.0	$19.70	$22.24	2.88	$0.47	$63.17	$57.29
2012	13.8	86.2	$19.70	$22.24	2.80	$0.46	$61.86	$55.91

Table 202-8						
FMVSS No. 202 Head Restraints Front Seat - Passenger Cars						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	0.53	0.00	0.53	$8.05	$0.00	$8.05
1969	0.53	3.86	4.39	$6.05	$44.34	$50.39
1970	0.51	3.75	4.26	$5.60	$41.10	$46.70
1971	0.50	3.64	4.14	$5.30	$38.88	$44.18
1972	0.48	3.53	4.01	$5.09	$37.33	$42.42
1973	0.47	3.41	3.88	$4.92	$36.09	$41.01
1974	0.45	3.30	3.76	$4.81	$35.29	$40.10
1975	0.44	3.19	3.63	$4.72	$34.64	$39.36
1976	0.42	3.08	3.51	$4.63	$33.98	$38.62
1977	0.41	2.97	3.38	$4.55	$33.36	$37.91
1978	0.39	2.86	3.25	$4.47	$32.81	$37.29
1979	0.38	2.75	3.13	$4.41	$32.36	$36.78
1980	0.36	2.64	3.00	$4.37	$32.02	$36.39
1981	0.35	2.53	2.88	$4.33	$31.72	$36.05
1982	0.34	2.48	2.82	$4.39	$32.18	$36.57
1983	0.34	2.48	2.82	$4.35	$31.88	$36.23
1984	0.34	2.48	2.82	$4.30	$31.55	$35.85
1985	0.34	2.48	2.82	$4.26	$31.22	$35.48
1986	0.34	2.48	2.82	$4.21	$30.90	$35.12
1987	0.34	2.48	2.82	$4.18	$30.62	$34.80
1988	0.34	2.48	2.82	$4.14	$30.36	$34.50
1989	0.34	2.48	2.82	$4.11	$30.14	$34.25
1990	0.34	2.48	2.82	$4.08	$29.93	$34.01
1991	0.34	2.48	2.82	$4.06	$29.75	$33.81
1992	0.34	2.48	2.82	$4.03	$29.55	$33.58
1993	0.34	2.48	2.82	$4.00	$29.35	$33.36
1994	0.34	2.48	2.82	$3.97	$29.15	$33.12
1995	0.34	2.48	2.82	$3.95	$28.96	$32.91
1996	0.34	2.48	2.82	$3.92	$28.78	$32.70
1997	0.34	2.48	2.82	$3.90	$28.60	$32.50
1998	0.34	2.46	2.80	$3.91	$28.64	$32.55
1999	0.34	2.46	2.80	$4.08	$28.46	$32.54
2000	0.34	2.46	2.80	$4.06	$28.29	$32.35
2001	0.34	2.46	2.80	$4.04	$28.13	$32.16
2002	0.34	2.46	2.80	$4.01	$27.97	$31.99
2003	0.33	2.45	2.78	$4.02	$27.99	$32.00

2004	0.33	2.45	2.78	$4.00	$27.84	$31.84
2005	0.33	2.45	2.78	$3.98	$27.71	$31.69
2006	0.33	2.45	2.78	$3.96	$27.58	$31.54
2007	0.33	2.45	2.78	$3.94	$27.46	$31.41
2008	0.33	2.44	2.78	$3.94	$27.42	$31.36
2009	0.33	2.44	2.78	$3.94	$27.33	$31.27
2010	0.33	2.44	2.78	$3.94	$32.30	$36.24
2011	0.33	2.44	2.78	$3.94	$32.64	$36.58
2012	0.33	2.44	2.78	$3.94	$32.53	$36.47

Table 202-9

FMVSS No. 202 Head Restraints Rear Seat - Passenger Cars

Model Year	Weight (lb)			Consumer Cost (2012$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1991	0.00	0.00	0.00	$0.00	$0.00	$0.00
1992	0.38	0.00	0.38	$2.44	$0.00	$2.44
1993	0.76	0.00	0.76	$4.86	$0.00	$4.86
1994	1.14	0.00	1.14	$7.22	$0.00	$7.22
1995	1.55	0.00	1.55	$9.73	$0.00	$9.73
1996	1.94	0.00	1.94	$12.09	$0.00	$12.09
1997	2.32	0.00	2.32	$14.42	$0.00	$14.42
1998	2.71	0.00	2.71	$16.48	$0.00	$16.48
1999	3.18	0.00	3.18	$19.24	$0.00	$19.24
2000	3.87	0.00	3.87	$23.33	$0.00	$23.33
2001	4.65	0.00	4.65	$27.83	$0.00	$27.83
2002	5.42	0.00	5.42	$32.29	$0.00	$32.29
2003	6.34	0.00	6.34	$37.24	$0.00	$37.24
2004	7.28	0.00	7.28	$42.20	$0.00	$42.20
2005	8.26	0.00	8.26	$47.22	$0.00	$47.22
2006	8.42	0.00	8.42	$47.57	$0.00	$47.57
2007	8.59	0.00	8.59	$47.92	$0.00	$47.92
2008	8.76	0.00	8.76	$50.34	$0.00	$50.34
2009	8.83	0.00	8.83	$50.40	$0.00	$50.40
2010	8.83	0.00	8.83	$50.28	$0.00	$50.28
2011	9.49	0.00	9.49	$53.35	$0.00	$53.35
2012	9.55	0.00	9.55	$52.82	$0.00	$52.82

Table 202-10						
FMVSS No. 202 Head Restraints Front Seat - LTVs						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	0.43	0.00	0.43	$8.01	$0.00	$8.01
1969	0.43	0.00	0.43	$6.02	$0.00	$6.02
1970	0.43	0.00	0.43	$5.59	$0.00	$5.59
1971	0.43	0.00	0.43	$5.29	$0.00	$5.29
1972	0.43	0.00	0.43	$5.08	$0.00	$5.08
1973	0.43	0.00	0.43	$4.91	$0.00	$4.91
1974	1.00	0.00	1.00	$11.18	$0.00	$11.18
1975	1.00	0.00	1.00	$10.98	$0.00	$10.98
1976	1.00	0.00	1.00	$10.77	$0.00	$10.77
1977	1.00	0.00	1.00	$10.57	$0.00	$10.57
1978	1.00	0.00	1.00	$10.40	$0.00	$10.40
1979	1.00	0.00	1.00	$10.26	$0.00	$10.26
1980	1.00	0.00	1.00	$10.15	$0.00	$10.15
1981	1.00	0.00	1.00	$10.06	$0.00	$10.06
1982	1.00	0.00	1.00	$9.98	$0.00	$9.98
1983	1.69	0.00	1.69	$16.74	$0.00	$16.74
1984	1.96	0.00	1.96	$19.20	$0.00	$19.20
1985	2.24	0.00	2.24	$21.63	$0.00	$21.63
1986	2.30	0.00	2.30	$22.01	$0.00	$22.01
1987	2.67	0.00	2.67	$25.37	$0.00	$25.37
1988	2.53	0.00	2.53	$23.82	$0.00	$23.82
1989	2.42	0.00	2.42	$22.61	$0.00	$22.61
1990	2.42	0.47	2.89	$22.45	$4.34	$26.79
1991	2.42	0.51	2.93	$22.32	$4.72	$27.04
1992	2.42	1.74	4.16	$22.17	$15.93	$38.10
1993	2.42	1.74	4.16	$22.03	$15.82	$37.85
1994	2.42	1.74	4.16	$21.87	$15.71	$37.58
1995	2.42	1.74	4.16	$21.73	$15.61	$37.34
1996	2.42	1.74	4.16	$21.60	$15.51	$37.11
1997	2.42	1.74	4.16	$21.47	$15.42	$36.89
1998	2.28	1.64	3.92	$21.11	$15.16	$36.28
1999	2.28	1.64	3.92	$21.17	$15.07	$36.24
2000	2.28	1.64	3.92	$21.04	$14.98	$36.02
2001	2.28	1.64	3.92	$20.92	$14.89	$35.82
2002	2.28	1.64	3.92	$20.81	$14.81	$35.62
2003	2.61	1.87	4.48	$21.24	$15.12	$36.35

2004	2.61	1.87	4.48	$21.13	$15.04	$36.17
2005	2.61	1.87	4.48	$21.03	$14.97	$36.00
2006	2.61	1.87	4.48	$20.94	$14.90	$35.84
2007	2.61	1.87	4.48	$20.85	$14.84	$35.69
2008	2.69	1.93	4.63	$20.93	$14.89	$35.82
2009	2.69	1.93	4.63	$20.93	$14.80	$35.73
2010	2.69	2.73	5.42	$20.93	$19.75	$40.67
2011	2.69	2.80	5.49	$20.93	$20.08	$41.00
2012	2.69	2.80	5.49	$20.93	$19.96	$40.88

Table 202-11

FMVSS No. 202 Head Restraints Rear Seat - LTVs

Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1991	0.00	0.00	0.00	$0.00	$0.00	$0.00
1992	0.33	0.00	0.33	$1.44	$0.00	$1.44
1993	0.66	0.00	0.66	$2.86	$0.00	$2.86
1994	1.00	0.00	1.00	$4.25	$0.00	$4.25
1995	2.37	0.00	2.37	$10.06	$0.00	$10.06
1996	2.97	0.00	2.97	$12.49	$0.00	$12.49
1997	3.56	0.00	3.56	$14.90	$0.00	$14.90
1998	4.15	0.00	4.15	$17.28	$0.00	$17.28
1999	4.86	0.00	4.86	$20.21	$0.00	$20.21
2000	5.93	0.00	5.93	$24.50	$0.00	$24.50
2001	7.12	0.00	7.12	$29.23	$0.00	$29.23
2002	8.30	0.00	8.30	$33.92	$0.00	$33.92
2003	10.51	0.00	10.51	$42.66	$0.00	$42.66
2004	11.96	0.00	11.96	$48.30	$0.00	$48.30
2005	13.45	0.00	13.45	$54.00	$0.00	$54.00
2006	13.61	0.00	13.61	$54.36	$0.00	$54.36
2007	13.77	0.00	13.77	$54.72	$0.00	$54.72
2008	13.94	0.00	13.94	$55.55	$0.00	$55.55
2009	14.53	0.00	14.53	$57.71	$0.00	$57.71
2010	13.81	0.00	13.81	$54.89	$0.00	$54.89
2011	14.47	0.00	14.47	$57.29	$0.00	$57.29
2012	14.18	0.00	14.18	$55.91	$0.00	$55.91

<u>FMVSS No. 203, Impact protection for the driver from the steering control system</u>
<u>FMVSS No. 204, Steering control rearward displacement</u>

Passenger Car Studies

FMVSS No. 203/204 took effect on January 1, 1968, (passenger cars) and September 1, 1981, (multipurpose passenger vehicles, trucks, and buses). FMVSS No. 203 specifies requirements for steering control systems that yield forward, cushioning the impact of the driver's chest by absorbing much of his or her impact energy in front-end crashes. FMVSS No. 204 specifies requirements limiting the rearward displacement of the steering column into the passenger compartment. The purpose of these standards is to provide basic occupant protection for the unbelted or lap-belted driver in a frontal crash and minimize chest, neck, head, or facial injuries from an impact. This standard applies to passenger cars, multipurpose passenger vehicles, trucks, all LTVs, and buses with a GVWR of 10,000 pounds or less. Since the changes made to steering columns typically satisfied both of these standards, this analysis is combined into one section.

The final rule for passenger cars was published in the Federal Register on February 3, 1967, (32 FR 2414). The NPRM was published in the Federal Register on December 3, 1966, (31 FR 15212), making the baseline date September 1, 1966, or MY 1967. An estimated 63.37 percent of passenger cars had energy absorbing steering columns in MY 1967, and that level will be considered voluntary through MY 2012. Attributable costs will be the difference between the installation rate for MY 1968 at 100 percent and the voluntary baseline level of MY 1967, or 36.63 percent.

The requirements of FMVSS No. 203 and No. 204 address the hazards of a steering column in two different ways. FMVSS No. 203 requires that the impact force developed on the chest not to exceed a safe level of 2,500 pounds from the steering column during an impact of 15 mph. This is accomplished by designing the column to collapse at a controlled rate upon impact. FMVSS No. 204 specifies a limit of 5 inches horizontal steering column intrusion toward the driver during a head-on crash into a fixed barrier at 30 mph. Essentially, FMVSS No. 203 addresses the driver impacting the steering wheel/column and FMVSS No. 204 is concerned with the steering column being driven into the interior as the front of the vehicle is crushed during a crash. A collapsible steering column typically satisfied both requirements. It should be noted that FMVSS No. 203 does not apply as a separate requirement to vehicles that conform to the barrier crash standards of FMVSS No. 208 by means of air bags. FMVSS No. 203 extends past the weight class covered by FMVSS No. 208. FMVSS No. 203 goes to 10,000 lbs. GVWR and the air bag requirement in FMVSS No. 208 goes to 5,500 lbs. unloaded and 8,500 lbs. GVWR. Nevertheless, today's vehicles equipped with air bags still have collapsible steering columns since this device is an important component of the crush space and ride-down in the safety system that makes air bags effective.

Manufacturers replaced the rigid steering columns with different collapsible designs. American Motors, Chrysler, and General Motors had installed steering columns with the energy absorbing features on their 1967 models; whereas Ford, Toyota, Volkswagen, and, probably other foreign-based manufacturers introduced them in 1968. Three main components were modified to create a collapsible column: the outer jacket tube, the shift tube, and the steering shaft. The outer jacket is the visible external tube mounted to the firewall and instrument panel that contains the shift tube, the steering shaft, a wiring harness, and any internal energy absorbing components. The shift tube transfers the rotational input from the column mounted shift lever to the bottom of the steering column where linkage from the transmission is connected. The shift tube is oriented concentrically inside the outer jacket tube. The steering shaft transfers the rotational input from the steering wheel to the bottom of the steering column where it connects with the steering gearbox or an intermediate shaft. The steering shaft typically passes through the center of the column.

The outer jackets were weakened by cutting longitudinal slots in them (Ford), or by replacing a lower part of the jacket with a tube-shaped, basket-weave section of metal mesh (GM, Chrysler, AMC, VW, and Toyota). Later in 1969, AMC and GM started using an outer jacket composed of two concentric tubes, with the lower tube of a smaller diameter like a telescope. Between the outer diameter of the smaller tube and the inner diameter of the larger tube was a bearing sleeve that contained small hardened steel balls. During an impact, this outer jacket would collapse and absorb energy at a controlled rate as the steel balls cut grooves into the tubes. Chrysler maintained the basket-weave mesh design until the mid-1970s when they started placing a tapered collar/mandrel at the base of the outer jacket. As the column was loaded, the outer jacket would peel apart as it was pressed against the outer diameter of the collar and collapse at a controlled rate. Chrysler also introduced a wheel canister absorption device starting with the 1970 Dodge Challenger and Plymouth Barracuda in place of the energy-absorbing column. Volvo has also used wheel canisters. In 1973, Ford started installing an internally grooved column that uses friction between the column tubes to absorb energy.

The shift tube and the steering shaft were redesigned to collapse under impact. The shift tubes were designed to telescopically collapse with the outer jacket. The steering shaft was changed from a single rigid shaft to a two or three-piece shaft. The lower section on the two-piece shaft and the middle section on the three-piece shaft were hollow to allow the upper shaft to collapse into it.

One modification that could be attributed to FMVSS No. 204 was the change to the steering gearbox's intermediate shafts from a rigid to a collapsible design. These intermediate shafts span the distance from the lower end of the steering shaft to the steering gearbox mounted on the front sub-frame. Initially, a coaxial design where a smaller shaft slides into a larger hollow shaft was used to create a collapsible intermediate shaft. With the advent of rack and pinion steering, when the intermediate shaft usually became too short and too vertical to accommodate the coaxial design, two or more universal joints were used on the intermediate shaft to allow it to fold upon impact. The manufacturers of the vehicles studied made no major front structural changes in order to comply with FMVSS No. 204.

The shear capsule, which is a bracket designed to prevent rearward movement of the column but to allow forward movement, is a vital partner to the steering column energy-absorbing device. When the lower part of the column is forced backward due to vehicle damage, the shear capsule holds the upper column in place while the column EAD collapses. On the other hand, when the driver contacts the steering wheel, the shear capsule freely allows the upper part of the column to move forward while the EAD collapses.[79]

The steering assemblies and front structures of 1969-1976 post-standard passenger cars and their corresponding 1966 pre-standard make-models were examined to determine the weight and consumer cost of equipment changes in response to FMVSS No. 203/204.[80] Examination of the front structures indicated that the post-standard structures and their pre-standard counterparts were identical; no structural changes were made in response to the standard. Therefore, the weight and consumer cost estimates were based on the steering column assemblies. Three of the make-model passenger cars in the study (Rambler American, Volkswagen Beetle, and Toyota Corona) were not included in these estimates because there were no corresponding pre-standard model by the same manufacturer, so the weight and consumer cost added by the standard could not be accurately estimated. Furthermore, the steering column assembly of the 1968 Volkswagen Beetle used a simple mesh design that was soon modified and not a typical mesh-type column.

The cost analysis is subdivided into two sections:

- the steering assembly within the passenger compartment, and
- the steering assembly within the engine compartment.

The best estimate of the weight and consumer cost changes within the passenger compartment are obtained by subtracting the weight and consumer cost of the corresponding pre-standard steering column assembly from the weight and consumer cost of the post-standard steering column assembly. This cost analysis is based on six make-models where teardowns were performed on the 1969 and 1966 steering assemblies. The average incremental weight and consumer cost attributed to the standard is 1.89 pounds and $29.63 in 2012 dollars.

Within the engine compartment, an intermediate shaft is used between the steering column assembly and the steering gearbox in some cars with a forward-mounted steering gearbox. The engine compartment telescoping device, which was installed for the purpose of complying with FMVSS No. 204, was sometimes located on the intermediate shaft. Telescoping post-standard and rigid pre-standard intermediate shafts were examined. The post-standard shaft was found to cost $10.93 more in 2012 dollars and weigh about the same as the pre-standard design. This device is used in 39 percent of all passenger cars,[81] so the average cost per car is $4.26 in 2012 dollars.

Table 203/204-1 shows the average weight and consumer cost of steering assemblies attributable to FMVSS No. 203/204 in passenger cars.

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[79] Kahane, C. J. (1981). *An evaluation of Federal Motor Vehicle Safety Standards for passenger car steering assemblies, Standard 203 – Impact protection for the driver, Standard 204 – Rearward column displacement* (Report No. DOT HS 805 705), Washington, DC: National Highway Traffic Safety Administration.
[80] McLean, R. F., Eckel, C. E. B., & Lesczhik, J. A. (1980, May). *Cost evaluation for three Federal Motor Vehicle Standards FMVSS 203, 204, and 212* (Report No. DOT HS 805 602). Washington, DC: National Highway Traffic Safety Administration, Docket No. 2011-0066-0071.
[81] Kahane, DOT HS 805 705, 1981.

TABLE 203/204-1 AVERAGE WEIGHT AND CONSUMER COST OF STEERING ASSEMBLIES IN PASSENGER CARS FMVSS No. 203/204		
CATEGORY	**WEIGHT IN POUNDS**	**CONSUMER COST ($2012)**
Passenger	1.89	$29.63
Engine	0.00	$ 4.26
TOTAL	1.89	$33.89

An additional study was conducted on model-year 1983 passenger cars to determine the trend in weight and consumer cost of their steering column systems.[82] The entire sample of passenger cars studied had made extensive changes since the original post-standard vehicles. Unlike the 1968 and 1969 vehicles studied, every 1983 model-year passenger car studied used an intermediate steering shaft and two universal joints, which are necessary components of a rack and pinion steering system.

The design of the trend steering columns was affected in several ways by downsizing. Eight of the twelve 1983 vehicles studied used rack and pinion steering in place of the traditional worm and re-circulating ball gearbox type steering system. The downsized cars of 1983 were shorter in length from the windshield base to the front of the car; consequently, they had less room to package a steering system. Rack and pinion steering systems were mounted much closer to the firewall than the older systems with the steering gearbox located ahead of the front axle centerline. A steep angle resulted when the intermediate shaft was linked from the end of the steering column to the drive flange on the steering rack. This steep angle necessitated the use of universal joints on the ends of the intermediate shafts to allow the intermediate shaft to fold under impact. The universal joints added considerable cost to the intermediate shaft. A cheaper coaxial shaft would not function at these steep angles. The cost of the trend steering column was also affected by the increased use of floor shifts. Four of the vehicles studied used a floor shift for the transmission, eliminating the column shift tube altogether. The modest net overall decrease in weight and consumer cost of the trend steering columns, as compared to those of the standard year, are primarily the result of the trend steering columns being simpler and smaller. The various cost increasing and cost-savings factors essentially cancelled each other out, resulting in about the same net cost as in earlier years.

Table 203/204-2 shows the sales-weighted average weight and consumer cost of steering column assemblies for the pre-standard, standard, post-standard, and trend system passenger cars. It is important to note that there has been relatively little change to the weight and consumer cost between 1967 and 1983. Unlike Table 203/204-1, Table 203/204-2 computes the average total weight and consumer cost for all specimen vehicles in each model year group rather than the average incremental weight and consumer cost for matching make-models only (because the 1983 specimens did not match the earlier make-models).

[82] Osen, DOT HS 806 771, 1985.

TABLE 203/204-2 AVERAGE TOTAL WEIGHT AND CONSUMER COST OF STEERING COLUMN ASSEMBLIES IN PASSENGER CARS BY MODEL YEAR		
MODEL YEAR	**WEIGHT IN POUNDS**	**CONSUMER COST ($2012)**
1966 (Pre-Standard)	9.94	$30.08
1967-1968 (Standard)	10.90	$53.69
1969-1976 (Post-Standard)	12.41	$58.22
1983 (Trend)	11.90	$54.88

Table 203/204-3 shows the breakout of the weight and consumer cost of the different steering column designs. All six major energy absorbing design types are represented, as are the three largest U.S. auto manufacturers (Chrysler, Ford, and GM). Furthermore, there are multiple data points for the three most common energy absorbing design types (mesh, ball, and slotted columns).[83] Based on limited study samples, it appears that the costs of the various alternative collapsible column designs were fairly similar.

TABLE 203/204-3 AVERAGE INCREMENTAL WEIGHT AND CONSUMER COST BY STEERING COLUMN DESIGN FOR STEERING COLUMN ASSEMBLIES IN PASSENGER CARS (INCREASE RELATIVE TO MATCHING 1966 PRE-STANDARD ASSEMBLIES)		
DESIGN TYPE	**WEIGHT IN POUNDS**	**CONSUMER COST ($2012)**
Mesh	1.59	$28.73
Ball	1.06	$20.09
Slotted	1.30	$21.00
Grooved	0.53	$24.59
Slotted/Mandrel	0.62	$29.78
Wheel Canister	1.52	$26.22

Table 203/204-4 shows the resulting weight and consumer cost after applying the learning curve and the split between voluntary and attributable weight and cost.

[83] Kahane, DOT HS 805 705, 1981).

Table 203/204-4						
FMVSS No. 203/204 Steering Columns - Passenger Cars						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	1.20	0.69	1.89	$22.61	$13.07	$35.68
1969	1.20	0.69	1.89	$21.47	$12.41	$33.89
1970	1.20	0.69	1.89	$20.84	$12.05	$32.88
1971	1.20	0.69	1.89	$20.28	$11.72	$32.00
1972	1.20	0.69	1.89	$19.84	$11.47	$31.31
1973	1.20	0.69	1.89	$19.41	$11.22	$30.63
1974	1.20	0.69	1.89	$19.13	$11.06	$30.19
1975	1.20	0.69	1.89	$18.90	$10.92	$29.82
1976	1.20	0.69	1.89	$18.65	$10.78	$29.43
1977	1.20	0.69	1.89	$18.41	$10.64	$29.06
1978	1.20	0.69	1.89	$18.20	$10.52	$28.71
1979	1.20	0.69	1.89	$18.01	$10.41	$28.43
1980	1.20	0.69	1.89	$17.87	$10.33	$28.20
1981	1.20	0.69	1.89	$17.75	$10.26	$28.01
1982	1.20	0.69	1.89	$17.63	$10.19	$27.82
1983	1.20	0.69	1.89	$17.51	$10.12	$27.62
1984	1.20	0.69	1.89	$17.37	$10.04	$27.40
1985	1.20	0.69	1.89	$17.23	$9.96	$27.19
1986	1.20	0.69	1.89	$17.09	$9.88	$26.98
1987	1.20	0.69	1.89	$16.98	$9.81	$26.79
1988	1.20	0.69	1.89	$16.87	$9.75	$26.62
1989	1.20	0.69	1.89	$16.77	$9.70	$26.47
1990	1.20	0.69	1.89	$16.69	$9.65	$26.33
1991	1.20	0.69	1.89	$16.61	$9.60	$26.22
1992	1.20	0.69	1.89	$16.54	$9.56	$26.10
1993	1.20	0.69	1.89	$16.47	$9.52	$25.98
1994	1.20	0.69	1.89	$16.39	$9.47	$25.86
1995	1.20	0.69	1.89	$16.32	$9.43	$25.75
1996	1.20	0.69	1.89	$16.25	$9.39	$25.64
1997	1.20	0.69	1.89	$16.18	$9.35	$25.53
1998	1.20	0.69	1.89	$16.11	$9.31	$25.42
1999	1.20	0.69	1.89	$16.04	$9.27	$25.32
2000	1.20	0.69	1.89	$15.97	$9.23	$25.21
2001	1.20	0.69	1.89	$15.91	$9.20	$25.11
2002	1.20	0.69	1.89	$15.85	$9.16	$25.01
2003	1.20	0.69	1.89	$15.79	$9.13	$24.92

2004	1.20	0.69	1.89	$15.74	$9.10	$24.83
2005	1.20	0.69	1.89	$15.68	$9.06	$24.75
2006	1.20	0.69	1.89	$15.63	$9.04	$24.67
2007	1.20	0.69	1.89	$15.58	$9.01	$24.59
2008	1.20	0.69	1.89	$15.54	$8.98	$24.53
2009	1.20	0.69	1.89	$15.51	$8.97	$24.48
2010	1.20	0.69	1.89	$15.48	$8.95	$24.43
2011	1.20	0.69	1.89	$15.45	$8.93	$24.38
2012	1.20	0.69	1.89	$15.41	$8.91	$24.32

LTV Studies

FMVSS No. 203 and No. 204 were effective for LTVs on September 1, 1981. The final rule was published in the Federal Register on November 29, 1979, (44 FR 68470) extending the standard to LTVs. The NPRM was published in the Federal Register on November 9, 1978 (43 FR 52264), making the baseline date September 1, 1978, or MY 1979. An estimated 61.47 percent of LTVs had an energy absorbing steering column by MY 1979 the baseline year. All energy absorbing columns will be considered voluntary up through MY 1979 and that level will be held constant as voluntary compliance through MY 2012. Attributable costs will be the difference between the installation rate for MY 1979 and installation rates from MY 1980 to MY 2012. Table 203/204-6 shows the installation rates for energy absorbing steering columns estimated for passenger cars and LTVS.

Collapsible steering columns had already been installed in pickup trucks and multipurpose passenger vehicles from AMC, Chrysler, and GM before the standard was effective (as early as 1970 some LTVs). Collapsible steering columns were lacking mostly in full-sized vans with forward control steering systems where the more vertical angle of the column made it difficult to implement an energy-absorbing system.

Unlike passenger cars, NHTSA has not performed teardowns of complete steering assemblies in post-standard and matching pre-standard make-models of LTVs. However, steering columns with intermediate shafts from seven 1982 post-standard make-model LTVs and vans were torn down to determine their weight and consumer cost.[84] The contractor also estimated (without actual teardown) how much these columns would have cost if they had been rigid one-piece designs typical of pre-standard vehicles.

Table 203/204-5 shows the sales-weighted average weight and consumer cost of a steering column without energy absorbing columns (hypothetical estimate) and one with energy absorbing columns (actual teardown). The figures include the complete steering column and intermediate shaft, but not the steering wheel.

[84] Gladstone, Harvey, Lesczhik, & McLean, DOT HS 806 769, 1982, Docket No. 2011-0066-0053.

TABLE 203/204-5 ESTIMATED AVERAGE WEIGHT AND CONSUMER COST OF STEERING COLUMNS IN LTVS		
CATEGORY	**WEIGHT IN POUNDS**	**CONSUMER COST ($2002)**
Without Energy Absorbing Columns	10.13	$30.69
With Energy Absorbing Columns	10.76	$43.52
Estimated Incremental Weight & Cost	0.63	$12.83

The estimate in Table 203/204-5 is lower than the estimate for passenger cars (1.89 pounds and $33.89 in Table 203/204-1). The estimate for passenger cars is based on actual teardowns of matching pre- and post-standard specimens and considers the entire steering assembly; therefore, we believe it to be a more reliable estimate than Table 203/204-5, and we shall use it as our estimate for LTVs as well.

Table 203/204-7 shows the sales-weighted average weight and consumer cost of steering column assemblies attributable to FMVSS No. 203 and 204 in LTVs.

Table 203/204-6 Installation Rates of Energy Absorbing Columns in Percent Passenger Cars and LTVs		
Model Year	**Passenger Cars**	**LTVs**
1967	63.37	0
1968	100	0
1969	100	0
1970	100	3.21
1971	100	3.83
1972	100	1.81
1973	100	48.93
1974	100	49.23
1975	100	50.10
1976	100	53.66
1977	100	56.10
1978	100	55.01
1979	100	61.47
1980	100	78.22
1981	100	79.09
1982	100	100
1983	100	100
1984	100	100

1985	100	100
1986	100	100
1987	100	100
1988	100	100
1989	100	100
1990	100	100
1991	100	100
1992	100	100
1993	100	100
1994	100	100
1995	100	100
1996	100	100
1997	100	100
1998	100	100
1999	100	100
2000	100	100
2001	100	100
2002	100	100
2003	100	100
2004	100	100
2005	100	100
2006	100	100
2007	100	100
2008	100	100
2009	100	100
2010	100	100
2011	100	100
2012	100	100

Table 203/204-7						
FMVSS No. 203/204 Steering Columns - LTVs						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	0.00	0.00	0.00	$0.00	$0.00	$0.00
1969	0.00	0.00	0.00	$0.00	$0.00	$0.00
1970	0.06	0.00	0.06	$1.06	$0.00	$1.06
1971	0.07	0.00	0.07	$1.23	$0.00	$1.23
1972	0.03	0.00	0.03	$0.57	$0.00	$0.57
1973	0.92	0.00	0.92	$14.99	$0.00	$14.99
1974	0.93	0.00	0.93	$14.86	$0.00	$14.86
1975	0.95	0.00	0.95	$14.94	$0.00	$14.94
1976	1.01	0.00	1.01	$15.79	$0.00	$15.79
1977	1.06	0.00	1.06	$16.30	$0.00	$16.30
1978	1.04	0.00	1.04	$15.80	$0.00	$15.80
1979	1.16	0.00	1.16	$17.47	$0.00	$17.47
1980	1.16	0.32	1.48	$17.34	$4.72	$22.06
1981	1.16	0.33	1.49	$17.22	$4.93	$22.15
1982	1.16	0.73	1.89	$17.10	$10.72	$27.82
1983	1.16	0.73	1.89	$16.98	$10.64	$27.62
1984	1.16	0.73	1.89	$16.85	$10.56	$27.40
1985	1.16	0.73	1.89	$16.71	$10.47	$27.19
1986	1.16	0.73	1.89	$16.58	$10.39	$26.98
1987	1.16	0.73	1.89	$16.47	$10.32	$26.79
1988	1.16	0.73	1.89	$16.36	$10.26	$26.62
1989	1.16	0.73	1.89	$16.27	$10.20	$26.47
1990	1.16	0.73	1.89	$16.19	$10.15	$26.33
1991	1.16	0.73	1.89	$16.12	$10.10	$26.22
1992	1.16	0.73	1.89	$16.05	$10.06	$26.10
1993	1.16	0.73	1.89	$15.97	$10.01	$25.98
1994	1.16	0.73	1.89	$15.90	$9.96	$25.86
1995	1.16	0.73	1.89	$15.83	$9.92	$25.75
1996	1.16	0.73	1.89	$15.76	$9.88	$25.64
1997	1.16	0.73	1.89	$15.69	$9.84	$25.53
1998	1.16	0.73	1.89	$15.63	$9.80	$25.42
1999	1.16	0.73	1.89	$15.56	$9.75	$25.32
2000	1.16	0.73	1.89	$15.50	$9.71	$25.21
2001	1.16	0.73	1.89	$15.43	$9.67	$25.11
2002	1.16	0.73	1.89	$15.37	$9.64	$25.01
2003	1.16	0.73	1.89	$15.32	$9.60	$24.92

2004	1.16	0.73	1.89	$15.26	$9.57	$24.83
2005	1.16	0.73	1.89	$15.21	$9.53	$24.75
2006	1.16	0.73	1.89	$15.16	$9.50	$24.67
2007	1.16	0.73	1.89	$15.12	$9.47	$24.59
2008	1.16	0.73	1.89	$15.08	$9.45	$24.53
2009	1.16	0.73	1.89	$15.05	$9.43	$24.48
2010	1.16	0.73	1.89	$15.02	$9.41	$24.43
2011	1.16	0.73	1.89	$14.98	$9.39	$24.38
2012	1.16	0.73	1.89	$14.95	$9.37	$24.32

FMVSS No. 205, Glazing materials

FMVSS No. 205 took effect on January 1, 1968, and specifies requirements for glazing materials for use in motor vehicles and motor vehicle equipment. The purpose of this standard is to:

- reduce injuries resulting from impact to glazing surfaces,
- ensure a necessary degree of transparency in motor vehicle windows for driver visibility, and
- minimize the possibility of occupants being thrown through the vehicle windows in collisions.

This standard applies to glazing materials for use in passenger cars, multipurpose passenger vehicles, trucks, all LTVS, buses, motorcycles, slide-in campers, and pickup covers designed to carry persons while in motion.

Essentially, FMVSS No. 205 required that glazing materials used for windshields, windows, and interior partitions meet the requirements outlined in the industry's American National Standard Institute (ANSI) *Safety Code for Safety Glazing Materials for Glazing Motor Vehicles Operating on Land Highways*, Z-26.1 as issued in 1966. (The requirements were subsequently revised in Z26.1-1977, January 26, 1977, as supplemented by Z26.1a, July 3, 1980). ANSI Z26.1 outlines the requirements for all vehicle safety glazing materials, which include safety glass, safety plastic, multiple glazed units (two or more sheets of glazing separated by an air space), and bullet-resistant glazing. The standard specifies which type of glazing material can be in vehicle locations where driving visibility is required and not required. For passenger cars and LTVs, the industry used tempered glass for side and rear windows and laminated glass for windshields, although the standard allowed the use of other glazing materials in these locations as long as they met the material test requirements described in the standard.

ANSI Z26.1 defines tempered glass as a single sheet of specially treated (heat or chemically treated) plate, sheet, or float glass. It cannot be cut, drilled, or polished after treatment. When it is broken at any point, the entire piece immediately breaks into innumerable small pieces, which may be described as granular, usually with no large jagged edges. Tempered glass for use in locations other than windshields must pass tests for light stability, luminous transmittance, humidity, boil, ball impact, fracture, shot bag impact, and abrasion resistance. Tempered glass had been in use for many years before FMVSS No. 205, and the standard has not imposed any cost increases with its use.

ANSI Z26.1 defines laminated glass as two or more sheets of glass held together by a layer of plastic material. Under impact, laminated glass will crack or break but the pieces do not fly and the edges of holes are less jagged than ordinary glass. In addition to the tests required of tempered glass, laminated glass must also pass tests for deviation/distortion and penetration resistance.

Before MY 1966, the standard windshield for domestic cars was composed of a 0.015-inch layer of polyvinyl butyral tightly bonded between two 0.125-inch layers of plate glass.
Tests in the industry indicated that the plastic interlayer did not stretch more than the glass before the tight bond between the plastic and the glass caused tearing. Consequently, the plastic interlayer was easily torn by broken glass, allowing an occupant's head to tear through the windshield in low speed crashes causing disfiguring or disabling head injuries associated with windshield contact. In the early 1960s, it was discovered that a looser bond between the plastic and glass layers could be obtained by increasing the moisture content of the polyvinyl butyral, which set the stage for the development of improved windshields. In 1962 SAE requested glass companies develop a safer windshield, and the High Penetration Resistant (HPR) windshield was the response to that request.[85] The penetration resistance requirement was SAE standard J938, and first published in October 1965. FMVSS No. 205, effective in January 1968, was based largely on earlier SAE and ANSI standards; the installation of HPR windshields was the primary vehicle modification associated with those standards.

The NPRM was published in the Federal Register on December 3, 1966, (31 FR 15212) making the baseline date September 1, 1966, or MY 1967. Since 100 percent of the passenger car and LTV fleet met the proposal by MY 1967, the baseline date, there is no voluntary or attributable cost assigned for FMVSS No. 205.

High Penetration Resistant Windshield. The HPR windshield consisted of a 0.030-inch advanced plastic interlayer bonded between two pieces of glass by a special adhesive that permitted the plastic to slide along the glass and not delaminate or discolor. In 1965 the domestic manufacturers installed HPR windshields, on an experimental basis, in a few models. By 1966 every automobile manufacturer in the United States and Canada adopted the HPR windshield with the MY 1966 passenger car. These windshields remained unchanged until 1977 when thinner panes of glass (0.105-0.115 inch) were used to support vehicle downsizing.[86]

A study was conducted to determine the weight and consumer price differential between the pre-1966 glazing and the FMVSS No. 205 HPR windshield and tempered side and rear windows of MY 1969 passenger cars. The only variance in the windshield between the pre-standard and the HPR standard was the increase in thickness of the plastic interlayer from 0.015-inch to 0.030-

[85] Kahane, C. J., *An Evaluation of Windshield Glazing and Installation Methods for Passenger Cars*, Washington, DC: Department of Transportation, National Highway Traffic Safety Administration, 1985. (Report No. DOT HS 806 693).
[86] Gladstone, Harvey, Lesczhik, & McLean, DOT HS 806 769, 1982, Docket No. 2011-0066-0053.

inch and the use of an improved adhesive bonding material.[87] A representative sample of major domestic and foreign manufacturers was examined, and the sales-weighted average weight and consumer cost increase of an HPR windshield was calculated at 1.07 pounds and $9.35 in 2012 dollars.

HPR windshields were installed in all domestic vehicles for the MY 1966 in response to industry and SAE initiatives that preceded any Federal regulatory process, plus the majority of imported cars used an HPR windshield starting with the MY 1967. Therefore, the added weight and consumer cost is not attributed to FMVSS No. 205. The Federal standard essentially codified existing industry practices, and these practices were developed before the Federal government began to regulate motor vehicle safety.

Glass-Plastic Windshields. FMVSS No. 205 was amended in 1983 to permit, but not require, the use of glass-plastic glazing material at the option of the motor vehicle manufacturer. Glass-plastic windshields were thought to further reduce (over HPR windshields) occupant lacerations from impact with the windshield. This new windshield was essentially an HPR windshield with a layer of polyurethane bonded to the glass surface that faces the vehicle interior. This layer would provide a barrier that would prevent an occupant from contacting the broken shards of glass during an impact.[88] At the time of the amendment, the potential drawbacks of a glass-plastic windshield were thought to be:

- The lower abrasion resistance of the inside plastic layer could lead to degraded visibility and a shorter windshield lifespan, which would increase vehicle operation cost.
- The windshield is stiffer (four plies) and could contribute to a higher incidence of blunt impact injuries.
- The additional cost of a glass-plastic windshield on a new vehicle was estimated to be between $46.91 and $55.55 in 2012 dollars as compared to an HPR windshield.[89]
- Attachment of the rearview mirror to the plastic with adhesive was not practical. Other mounting schemes were needed.
- Attachments and removal of decals to the inside of the windshield may result in localized scratches and haze.

In the early 1980s Ford and GM installed glass-plastic windshields in rental vehicles for field-testing; however, the durability of these windshields in the real world was less than expected. The plastic inner liner was susceptible to damage (i.e., cuts, scratches) from the everyday operating environment. In 1984, GM installed the glass-plastic windshields as standard equipment in one of its luxury car models, the Cadillac Seville Elegante. By MYs 1986 and 1987, GM had made these windshields standard equipment on approximately 210,000 cars.[90]

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[87] Ibid.
[88] Parsons, G. G. (1993, November). *An evaluation of the effects of glass-plastic windshield glazing in passenger cars* (Report No. DOT HS 808 062) Washington, DC: National Highway Traffic Safety Administration. .
[89] *Final Regulatory Evaluation Anti-Lacerative Glazing FMVSS 205*, Washington, DC: National Highway Traffic Safety Administration, September 1983, pg. IV-2.
[90] Parsons, 1993.

The actual cost of glass-plastic windshields in use was greater than estimated in the 1983 amendment. The estimated cost increase of a glass-plastic windshield in 1983 was between $77.77 and $92.59 in 2012 economics. This estimate was from the sole supplier of glass-plastic glazing at the time and was based on a production volume of 500,000 to 1,000,000 units annually. In reality, much lower production volumes resulted in higher costs. After the 1987 model year, GM no longer installed glass-plastic windshields in any vehicles due to high warranty and replacement costs, and no other domestic or import automaker has used them in their U.S. market vehicles since.

A small percentage of new vehicles are being equipped with laminated glass in the side windows. NHTSA researched laminated glass as a countermeasure for occupant ejection through the side window, eventually deciding that the countermeasure of choice would be ejection mitigating window curtains. It appears that laminated glass is more likely to be selected for use in side windows as a security measure, rather than a safety measure. While no laminated glass has been used to meet a NHTSA standard through MY 2012, there may be some non-movable windows for which laminated glass is used for safety as the ejection mitigation rulemaking becomes effective.

No incremental weight or cost has been added to this analysis associated with FMVSS No. 205.

FMVSS No. 206, Door locks and door retention components

FMVSS No. 206 took effect on January 1, 1968, (passenger cars), January 1, 1970, (multipurpose passenger vehicles), and January 1, 1972, (trucks) and specifies requirements for door locks and door retention components including latches, hinges, and other supporting means. The purpose of this standard is to minimize the likelihood of occupants being thrown from the vehicle as a result of impact. This standard applies to passenger cars, multipurpose passenger vehicles, and trucks (all LTVs).

Side Door Components. Door latches were required to have a fully latched position and a secondary latched position, which were required to withstand a 2,500-pound longitudinal load in the fully latched position and 1,000 pounds in the secondary latched position. In the transverse direction, the latch must withstand a 2,000-pound load when fully engaged and a 1,000-pound load in the secondary latched position. Door latches were also required not to move from the fully engaged position when a longitudinal or transverse inertial load of 30g was applied to the door latch system. Similarly, door hinges were required to sustain loads of 2,500 pounds longitudinal and 2,000 pounds transverse without failure.

FMVSS No. 206 had a regulatory history that began before NHTSA was founded. Specifically, it incorporated two SAE standards developed by the domestic auto industry. The standard gradually evolved and became stronger throughout 1962-1969. The manufacturers who often anticipated the regulations and steadily improved their door locks throughout 1956-1969 voluntarily implemented most of these improvements.[91] Therefore, no cost studies have been

[91] Kahane, C. J. (1989, November). *An evaluation of door locks and roof crush resistance of passenger cars – Federal Motor Vehicle Safety Standards 206 and 216* (Report No. DOT HS 807 489).Washington, DC: National Highway Traffic Safety Administration.

performed on door latches, hinges, and other retention components for side doors, and none are planned by NHTSA.

Back Door Components.

In September 28, 1995, (60 FR 50124), a final rule amending FMVSS No. 206 was published that extended the side door requirements to the back doors of passenger cars and multipurpose passenger vehicles. This ruling affected hatchbacks, stations wagons, SUVs, and passenger vans with a GVWR of 10,000 pounds or less. The NPRM was published in the Federal Register on August 30, 1994, (59 FR 44691). Sixty percent of the affected vehicles were required to comply by September 1, 1997, with 100 percent by September 1, 1998. The intent of the amendment is to prevent occupant ejections from vehicles equipped with back doors.

In March 1994 NHTSA published a press release warning owners of minivans and other vehicles with hatchbacks that these doors can open unexpectedly in a crash and unbelted occupants can be ejected. A cost and weight analysis was performed on latch/striker assemblies from the back doors of two 1993 (pre-standard) minivans.[92] One of the assemblies met the side door latch strength requirements of FVMSS 206 while the other did not. The latch/striker assembly that passed the 206 testing weighed 0.86 pounds and cost an estimated $4.11 in 2012 dollars, while the latch/striker assembly that failed weighed 0.90 pounds and cost an estimated $5.63 in 2012 dollars. A comparison of the test results and cost analysis leads to the conclusion that a latch/striker that meets the requirements of FMVSS No. 206 in this case did not cost more than a latch/striker that does not meet the standard. Therefore, an increase in the weight and consumer cost of back door latches has not been attributed to the standard. However, a more detailed teardown analysis of a representative sample of pre- and post-standard make-models would be needed to confirm this initial no-cost estimate.

Sliding Door Components.

On February 6, 2007, (72 FR 53385), NHTSA issued a final rule which amended the safety standard on door locks and door retention components and updated the requirements and test procedures to harmonize with the world's first global technical regulation for motor vehicles. The final rule added new test requirements and test procedures for sliding doors, added secondary latch position requirements for doors other than hinged side doors and back doors and extended the application of the standard to buses with a GVWR of 10,000 pounds or less, including 12- to 15-passenger vans. The effective date was September 1, 2009.

The NPRM was published in the Federal Register on December 15, 2004, (69 FR 75020), making baseline date September 1, 2004, or MY 2005. Since 100 percent of the fleet did not meet the sliding door test procedures by the baseline date, costs will all be considered voluntary through MY 2005 and the voluntary percentage will be held at that MY 2005 baseline level through MY 2012. Attributable costs will be the difference between the compliance rates for MY 2006 to MY 2012 minus the voluntary baseline level of MY 2005.

The only cost and weight impact of the amendments was to sliding doors. The significant factor in

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[92] Rutland, K. W., & Spinney, B. C. (1994, May). *A cost and weight analysis of MY 93 minivan rear door latch and striker sets* (NHTSA internal document). Washington, DC: National Highway Traffic Safety Administration.

passing the new requirements were whether the sliding door was attached by a latch on both sides of the door or by a latch on one side and a pin on the other. All sliding doors attached by two latches passed the test and none of those with a pin on one side passed, failing always on the side with the pin.

The Final Regulatory Evaluation[93] estimated that the cost to add a second latch to a sliding door was $8.64 in 2012 economics. The latch in a sliding door is similar to the latch used in all passenger car and LTV doors. While NHTSA did not have a cost teardown of a sliding door latch, we had a cost teardown of several other door latches.[94] The latch cost of the MY 1995 Ford F150, MY 1995 Dodge Ram, MY 1975 Chevy Malibu, MY 1976 Ford Escort, and a F100 Pickup were averaged at $9.21. The pin was estimated to cost $0.57, thus the incremental cost per latch was $8.64 in 2012 economics.

The weight of the latch was taken from the report[95] on the weight of the MY 1979 and 1980 Ford F-150 pickup truck. The weight of one latch was 1.16 pounds and the weight of the striker was 0.21 pounds. It is assumed that the weight of the pin would be close to the weight of the striker and that the net weight would be the weight of the latch or 1.16 pounds.

All of the full size vans had 2 latches and would pass the test. The standard essentially did not change full size vans. The equipment was already in place well before any rulemaking process was underway and the standard essentially mandated what had already long been there. This standard does not add cost to the full size vans, and the cost of the equipment that was already there will not be considered voluntary or attributed to the FMVSS. In this case, every full size van met the standard long before the rulemaking process began and no full size vans were changed as a result of the standard. Thus, full size vans are not counted as being affected by the standard and are not considered as voluntary costs.

Some minivans had a pin attachment and needed a second latch to comply. Other minivans had a second latch and we will consider all installations meeting the standard for mini-vans up to the baseline year of MY 2005 as voluntary. We will assume costs for mini-vans from MY 2006 on that are above the baseline levels to be attributed to the standard. Many of the minivans had two sliding doors installed (one on each side).

For FMVSS No. 206 we did not base the learning curve on sliding door sales, since the latch technology is essentially the same that has been used on all side doors for many years. Doing so would have resulted in a very steep learning curve and very high costs for the early years because minivan sales are not large and only started in MY 1984. Instead we assumed a learning curve based on 100 percent of passenger cars and LTVs using latches from MY 1960 on. The learning curve thus reflects the cumulative production experience of latches rather than sliding doors.

[93] NHTSA, *Final Regulatory Evaluation, Door Latch Test Procedures, FMVSS No. 206,* February 2006, Docket No. 2006-23882-0002.

[94] Ludtke & Associates, *Cost, Weight and Lead Time Analysis, FMVSS No. 206 Door Lock/Latches – Upgrade of Test Procedures Final Report Volume 1*, April 30, 2001.

[95] Ludtke & Associates . (1980, March). *1980 and 1979 Ford F-150 LTV weight and material analysis* (Report No. DOT HS 805 693, Docket No. 2011-0066-0070, Page A-25. Washington, DC: National Highway Traffic Safety Administration.

We examined the sales of minivans, the number of sliding doors per minivan, weighted compliance with FMVSS No. 206 over time, and determined the percentage of sales of minivans compared to all LTVs to determine the average cost for all LTVs for each model year. Table 206-1 shows the results of these interim steps in the calculations.

Table 206-2 presents the average weight and cost for LTVs.

Table 206-1
Factors Affecting FMVSS 206 for LTVs

Model Year	Minivan % of LTV sales	Ave. # Doors per Minivan	Ave. Percent Complying Latches Per Door	Combined Latches per LTV
1984	1.91	1.00	0.00	0
1985	9.58	1.00	0.20	0.019
1986	13.09	1.00	0.33	0.043
1987	14.98	1.00	0.33	0.049
1988	15.19	1.00	0.32	0.049
1989	17.71	1.00	0.25	0.044
1990	20.32	1.00	0.30	0.062
1991	21.18	1.00	0.28	0.060
1992	21.00	1.00	0.28	0.059
1993	21.19	1.00	0.34	0.072
1994	20.86	1.00	0.39	0.081
1995	20.46	1.02	0.40	0.082
1996	18.49	1.21	0.30	0.067
1997	17.98	1.37	0.38	0.095
1998	16.51	1.46	0.43	0.104
1999	16.36	1.52	0.45	0.112
2000	16.13	1.59	0.42	0.109
2001	13.63	1.78	0.39	0.094
2002	13.02	1.81	0.35	0.082
2003	11.90	1.84	0.36	0.079
2004	11.87	1.95	0.40	0.093
2005	11.91	1.94	0.38	0.088
2006	11.13	1.97	0.54	0.119
2007	9.37	1.99	0.55	0.102
2008	9.28	2.00	0.54	0.101
2009	8.48	1.99	0.52	0.088
2010	8.24	1.97	1.00	0.162
2011	7.60	1.97	1.00	0.150
2012	8.09	1.97	1.00	0.159

Table 206-2						
FMVSS No. 206 Sliding Doors - LTVs						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1984	0.00	0.00	0.00	0.00	0.00	0.00
1985	0.02	0.00	0.02	0.16	0.00	0.16
1986	0.05	0.00	0.05	0.35	0.00	0.35
1987	0.06	0.00	0.06	0.39	0.00	0.39
1988	0.06	0.00	0.06	0.39	0.00	0.39
1989	0.05	0.00	0.05	0.36	0.00	0.36
1990	0.07	0.00	0.07	0.49	0.00	0.49
1991	0.07	0.00	0.07	0.47	0.00	0.47
1992	0.07	0.00	0.07	0.47	0.00	0.47
1993	0.08	0.00	0.08	0.56	0.00	0.56
1994	0.09	0.00	0.09	0.63	0.00	0.63
1995	0.10	0.00	0.10	0.65	0.00	0.65
1996	0.08	0.00	0.08	0.53	0.00	0.53
1997	0.11	0.00	0.11	0.74	0.00	0.74
1998	0.12	0.00	0.12	0.80	0.00	0.80
1999	0.13	0.00	0.13	0.86	0.00	0.86
2000	0.13	0.00	0.13	0.84	0.00	0.84
2001	0.11	0.00	0.11	0.72	0.00	0.72
2002	0.10	0.00	0.10	0.63	0.00	0.63
2003	0.09	0.00	0.09	0.60	0.00	0.60
2004	0.11	0.00	0.11	0.71	0.00	0.71
2005	0.10	0.00	0.10	0.67	0.00	0.67
2006	0.10	0.04	0.14	0.67	0.23	0.90
2007	0.10	0.02	0.12	0.67	0.10	0.77
2008	0.10	0.01	0.12	0.67	0.09	0.76
2009	0.10	0.00	0.10	0.67	0.00	0.67
2010	0.10	0.09	0.19	0.66	0.56	1.22
2011	0.10	0.07	0.17	0.66	0.46	1.12
2012	0.10	0.08	0.18	0.66	0.53	1.19

FMVSS No. 207, Seating systems

FMVSS No. 207 took effect on January 1, 1968, (passenger cars) and January 1, 1972, (multipurpose passenger vehicles, trucks, (all LTVs), and buses) and specifies requirements for seats, their attachment assemblies, and their installation. The purpose of this standard is to minimize the possibility of their failure by forces acting on them as a result of vehicle impact.

The standard requires that each occupant seat installation, except for folding auxiliary jump seats and side-facing seats, shall withstand a load of twenty times the weight of the seat in a forward and rearward longitudinal direction and withstand a 3,300 inch pound moment about the seat's H point (location, when viewed from the side, where an occupant's hips would reside when sitting in the seat). Folding and hinged seats are required to have a self-locking restraining device for the seat back with a release control to allow the seat back to be folded forward. The restraining device must preclude inertial release when subjected to a 20g longitudinal load. Additionally, the restraining device must withstand a forward longitudinal load of twenty times the weight of the seat back applied to the center of gravity of the seat back without failing or releasing.

FMVSS No. 207 is essentially associated with one tangible vehicle modification: the introduction of seat back locks in the folding front seat backs of passenger cars with two doors. Folding and hinged seats were not necessary in 4-door vehicles. On a model year basis, the percentage of 2-door cars sold has decreased fairly steadily from a high of 64 percent in 1974 to 12.3 percent in 2012.

On February 3, 1967, (32 FR 2414) a final rule requiring seat back locks was published in the Federal Register and it has only affected passenger cars. The NPRM was published in the Federal Register on December 3, 1966, (31 FR 15212) making the baseline date September 1, 1966, or MY 1967. Seat back lock costs will all be considered voluntary through MY 1967 and the voluntary percentage will be held at that MY 1967 baseline level through MY 2012. Attributable costs will be the difference between the installation rates for MY 1968 to MY 2012 minus the voluntary baseline level of MY 1967. An estimated 29.5 percent of all passenger cars (57% of the 2-door passenger cars) had seat back locks in MY 1967 and all MY 1968 2-door passenger cars had seat back locks. Thus, voluntary compliance is 57 percent and attributable compliance is 43 percent of total compliance in MY 1968 to MY 2012.

Seat mounting assemblies and floor panels on twelve MY 1969 United States-manufactured passenger cars were examined to determine the impact of FMVSS No. 207. There were no apparent modifications to the seat mounting assemblies or the floor panels under the seats on any of the vehicles examined. The manual seat back locks from four 1969 model year 2-door passenger cars (Ford Mustang, Ford Thunderbird, Chevrolet Nova, and Pontiac Firebird) were examined to determine their cost and weight.[96] The results of the first three cars were reasonable and consistent, especially since the Mustang had a simpler lever for operating the seat back lock than did the Thunderbird and Nova. The much lower results for the Firebird were anomalous, especially since the photographs suggested it had almost the same hardware as the Mustang. In addition, the report gave two conflicting values for added weight intimating that the cost estimates for the Firebird were incorrectly calculated or transcribed in several categories. Only the results for the first three vehicles were used for computing the average. Automatic (inertial) seat back locks from three MY 1986 passenger cars (Chevrolet Camaro, Dodge 400, and Ford Tempo) were also studied.[97]

[96] Harvey, Lesczhik, & McLean, 1979, Docket No. 2011-0066-0075.
[97] Carlson & Leonard, 1986.

Seat back locks were implemented at General Motors in 1967 and at Ford and Chrysler in 1968. In addition Volkswagen and Opel contained seat back locks by 1966 and Fiat, Renault, Datsun, and Sunbeam by 1967.[98]

The percentage of passenger cars that are 2-door cars that had seat back locks in MY 1967 is not easy to estimate. The 1975 Polk NVPP file (the earliest one we have) gives you an accurate estimate that 50.75 percent of MY 1967 GM cars (i.e., the 1967 GM cars that were still on the road on 07/01/1975) were 2-door. Although the 1975 Polk NVPP file has registrations for each of the import manufacturers listed above for MY 1967, the number of doors is unknown for all except VW, and there it is either unknown or 2-door. In the case of Sunbeam it doesn't matter, because Sunbeam was a sports car and all were 2-door. For most of these manufacturers, except VW, we did find a distribution of 2-door and 4-door for MY 1968 or MY 1969 vehicles and used that as a proxy measure for MY 1967, because there were many more vehicles here than in FARS.

For VW we used the distribution of BODY_TYP for the vehicles that were in fatal crashes and thus in FARS. We used the first 6 years of FARS (1975-1980), because after that, given the shorter lifespans of cars in those days, there were probably few MY 1966 or 1967 models on the road after 1980. FARS gives us pretty useful distributions for VW (88.1 percent were 2-door passenger cars), Datsun, Fiat, and Opel. The 2-door distributions found in FARS for Datsun, Fiat, and Opel were very similar to the MY 1968 or MY 1969 distributions found in the 1975 Polk NVPP file. There are very few Renault vehicles in the FARS files and all were 4-doors. An examination of the models sold worldwide by Renault in 1967 shows several 4 door models and only one 2-door sports car that might not have been sold in the United States. Thus, we assume all Renaults are 4-door cars and would not have seat back locks. The result of this analysis is an estimate that 29.5 percent of the MY 1967 baseline passenger cars had seat back locks.

Initially all seat back locks were the manual type. Persons desiring to enter the rear seat of a 2-door car could not fold over the front seat back until they disengaged the lock by operating a lever or pressing a button. Around 1980, the domestic manufacturers switched to automatic inertial seat back locks, which operate much like inertial seat belt retractors. The front seat back folds over freely except during the moments when the car is subjected to decelerations by impacts, road bumps, or emergency braking. During a frontal crash, an inertial mechanism automatically locks the seat back in place.

Table 207-1 shows the arithmetic average weight and consumer cost of manual and automatic seat back locks for 2-door passenger cars. On average, the automatic seat back locks weighed more than, and cost about the same as, the manual locks. Since seat back locks were an addition to the seat, their weight and consumer cost is attributed to FMVSS No. 207 but only in 2-door passenger cars. The cost of manual seat back locks will be used for MYs 1968-1979 (without the use of the learning curve), while the cost of automatic seat back locks will be used for MYs 1980-2012 (with the learning curve being applied using the cost of the automatic seat back locks in the equation).

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[98] Costenoble, K., & Northrop, G. M. (1978). *Review of nine Federal Motor Vehicle Safety Standards*(Report No. 4238/4239-601). Hartford: Center for the Environment and Man.

TABLE 207-1 AVERAGE WEIGHT AND CONSUMER COST OF SEAT BACK LOCKS IN 2-DOOR PASSENGER CARS ATTRIBUTABLE TO FMVSS No. 207		
CATEGORY	WEIGHT IN POUNDS	CONSUMER COST ($2012)
Manual (1968-1979)	3.07	$20.41
Automatic (1980-2012)	3.96	$19.91

Table 207-2 provides the average weight and consumer cost per passenger car. Seat back locks were generally not used in LTVs.

Table 207-2 FMVSS No. 207 Seat Back Locks - Passenger Cars							
Model Year	Percent 2-doors	Weight (lb)			Consumer Cost (2012$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	54.20	0.95	0.72	1.66	$6.30	$4.76	$11.06
1969	54.82	0.96	0.72	1.68	$6.38	$4.81	$11.19
1970	57.94	1.01	0.76	1.78	$6.74	$5.08	$11.82
1971	58.43	1.02	0.77	1.79	$6.80	$5.13	$11.92
1972	56.15	0.98	0.74	1.72	$6.53	$4.93	$11.46
1973	57.79	1.01	0.76	1.77	$6.72	$5.07	$11.79
1974	64.32	1.13	0.85	1.97	$7.48	$5.64	$13.13
1975	61.32	1.07	0.81	1.88	$7.13	$5.38	$12.51
1976	60.91	1.07	0.80	1.87	$7.08	$5.34	$12.43
1977	59.15	1.04	0.78	1.82	$6.88	$5.19	$12.07
1978	58.51	1.02	0.77	1.80	$6.81	$5.13	$11.94
1979	59.96	1.05	0.79	1.84	$6.97	$5.26	$12.24
1980	58.06	1.31	0.99	2.30	$6.75	$5.09	$11.85
1981	49.72	1.12	0.85	1.97	$5.77	$4.36	$10.13
1982	45.83	1.03	0.78	1.81	$5.30	$4.00	$9.29
1983	41.07	0.93	0.70	1.63	$4.73	$3.57	$8.29
1984	41.56	0.94	0.71	1.65	$4.76	$3.59	$8.35
1985	38.59	0.87	0.66	1.53	$4.40	$3.32	$7.72
1986	37.42	0.84	0.64	1.48	$4.25	$3.20	$7.45
1987	34.93	0.79	0.59	1.38	$3.95	$2.98	$6.93
1988	37.78	0.85	0.64	1.50	$4.26	$3.21	$7.47
1989	38.32	0.86	0.65	1.52	$4.30	$3.25	$7.55
1990	32.97	0.74	0.56	1.31	$3.69	$2.78	$6.48
1991	31.77	0.72	0.54	1.26	$3.55	$2.68	$6.23
1992	27.78	0.63	0.47	1.10	$3.10	$2.34	$5.43
1993	28.35	0.64	0.48	1.12	$3.15	$2.38	$5.53

1994	27.95	0.63	0.48	1.11	$3.10	$2.34	$5.44
1995	26.03	0.59	0.44	1.03	$2.88	$2.18	$5.06
1996	23.5	0.53	0.40	0.93	$2.60	$1.96	$4.56
1997	21.57	0.49	0.37	0.85	$2.38	$1.80	$4.18
1998	19.61	0.44	0.33	0.78	$2.16	$1.63	$3.80
1999	19.73	0.45	0.34	0.78	$2.17	$1.64	$3.82
2000	19.08	0.43	0.32	0.76	$2.10	$1.58	$3.68
2001	18.66	0.42	0.32	0.74	$2.05	$1.55	$3.60
2002	17.68	0.40	0.30	0.70	$1.94	$1.46	$3.41
2003	15.87	0.36	0.27	0.63	$1.74	$1.31	$3.06
2004	17.21	0.39	0.29	0.68	$1.89	$1.42	$3.31
2005	14.33	0.32	0.24	0.57	$1.57	$1.18	$2.75
2006	15.08	0.34	0.26	0.60	$1.65	$1.25	$2.90
2007	14.26	0.32	0.24	0.56	$1.56	$1.18	$2.74
2008	14.53	0.33	0.25	0.58	$1.59	$1.20	$2.79
2009	14.65	0.33	0.25	0.58	$1.60	$1.21	$2.81
2010	13.51	0.30	0.23	0.53	$1.47	$1.11	$2.59
2011	10.81	0.24	0.18	0.43	$1.18	$0.89	$2.07
2012	12.29	0.28	0.21	0.49	$1.34	$1.01	$2.35

FMVSS No. 208, Occupant crash protection
FMVSS No. 209, Seat belt assemblies
FMVSS No. 210, Seat belt assembly anchorages

FMVSS No. 208 was proposed on December 3, 1966, (31 FR 15212) with a group of initial FMVSS. The final rule was published on February 3, 1967, (32 FR 2414). The final rule for FMVSS No. 208 took effect on January 1, 1968, (passenger cars) and July 1, 1971, (multipurpose passenger vehicles, trucks, (all LTVs), and buses). It was the basic crash protection standard and initially defined the requirements for the installation of seat belts in passenger cars. The standard was amended to specify performance requirements for anthropomorphic test dummies seated in the outboard front seats of passenger cars and certain multipurpose passenger vehicles, trucks, and buses for manual and automatic restraint systems. It subsequently required and set performance levels for automatic crash protection, especially air bags.

FMVSS No. 209 took effect on January 1, 1968, and specifies requirements for seat belt assemblies. It applies to the seat belt assembly itself and the vehicle. The requirements apply to:

- Straps, webbing, or similar material,
- All necessary buckles and other fasteners,
- All hardware designed for installing the assembly in a motor vehicle, and
- Installation, labeling, usage, and maintenance instructions for the assembly.

FMVSS No. 210 took effect on January 1, 1968, (passenger cars) and July 1, 1971, (multipurpose passenger vehicles, trucks, (all LTVs) and buses) and establishes requirements for seat belt assembly anchorages. The purpose of this standard is to ensure proper location for effective occupant restraint and to reduce the likelihood of failure. The requirements apply to any component, other than the webbing or straps, involved in transferring seat belt loads to the vehicle structure.

The purpose of FMVSS Nos. 208, 209, and 210 are to reduce the number of fatalities and the number and severity of injuries to occupants involved in crashes. Seat belts that meet these standards offer protection in crashes of all types, e.g., front, side, rollover. Many of the requirements of FMVSS No. 208 that pertain to frontal air bags are focused on frontal crash protection. These standards apply to passenger cars, multipurpose passenger vehicles, trucks, (all LTVs), and buses. Since FMVSS Nos. 209 and 210 support the hardware requirements of FMVSS No. 208, these standards have been combined into this analysis with FMVSS No. 208. Not all of the early cost teardown studies of seat belts included costs for anchorages. For this report, weight and cost estimates for anchorages meeting FMVSS No. 210 were added to the early cost teardown studies where necessary.[99] The anchorages for passenger cars were a little more expensive than the anchorages for LTVs. The later cost teardown studies of manual or automatic seat belts specifically included the weights and costs for anchorages meeting FMVSS No. 210.

This analysis of FMVSS 208 focuses on the safety countermeasures and seating positions for passenger cars and LTVs separately. We consider lap belts, lap/shoulder belts, automatic belts, driver air bags, passenger air bags, advanced air bags, pretensioners and load limiters, and manual on/off switches for right front passenger air bags for the following seating positions where applicable – front outboard seat, front center seat, rear outboard seat, and rear center seat. We focus on the installation rates of these safety features and the baseline year related to the most important NPRMs that resulted in these safety features being implemented. There were many stops and starts to automatic restraints and air bags with many NPRMs that did not materialize into a final rule. Thus, we focus on the NPRMs that led to final rules that resulted in the safety features becoming widely popular.

Before NHTSA was established, many States were requiring lap belts in motor vehicles[100]. Illinois was the first State to require lap belts in the front outboard seats of passenger cars, effective with the 1961 model year. As of December 31, 1963, there were 23 States that had laws requiring lap belts that were effective at various times; 16 of those State laws were effective by January 1, 1964. As of January 1, 1968, the effective date of NHTSA's requirements for lap belts in passenger cars, 34 States required lap belts for at least the front outboard seats of passenger cars. As of January 1, 1968, New York and Texas required lap belts for the front outboard seats of all LTVs and Iowa required lap belts for the front outboard seats of pickup trucks. As the

[99] Osen, W. R., & Ludtke, N. F. (1985, April). *Cost evaluation of Federal Motor Vehicle Standard 210, passenger cars, and the cost and weight trends for Standards 201,203,and 204, passenger cars, volume III*(Report No. DOT HS 806 772), Docket No. 2011-0066-0050. Washington, DC: National Highway Traffic Safety Administration.
[100] National Committee on Uniform Traffic Laws and Ordinances. (1972, October). *Laws requiring seat belts*, (Traffic Law Commentary series, Volume 1, Number 6. Report No. DOT HS 820 226). Washington, DC: National Highway Traffic Safety Administration. Available at http://ntl.bts.gov/lib/25000/25300/25318/DOT-HS-820-226.pdf

number of States requiring lap belts increased, manufacturers inevitably began installing them in all vehicles. It becomes impractical to maintain separate assembly and shipping operations for different States. State requirements thus resulted in all passenger cars being produced with lap belts in the front outboard seats by MY 1967.

The first NPRM on FMVSS No. 208 was published in the Federal Register on December 3, 1966 (31 FR 15212) making the baseline date September 1, 1966, or MY 1967. Since lap belts were provided for 100 percent of passenger cars for all seating positions by the baseline date, the definitions developed for this analysis would mean that lap belts were the baseline. This means that there would be no cost for lap belts and when we considered lap/shoulder belts that the cost of lap belts would be subtracted from the cost of lap/shoulder belts to get the incremental cost above the baseline. However, it was hard to argue that lap belts were voluntarily provided when State laws were requiring the manufacturers to provide lap belts. Since many State laws were passed and effective before NHTSA was established, it did not seem appropriate to set a baseline date (that determines voluntary versus attributable) that was limited by when NHTSA was established. Thus, we decided to make an exception in the case of lap belts, and recognize that they are attributable to safety standards (although in this case it is the State safety standards and not the FMVSS). We have thus attributed the cost of all lap belts, in both passenger cars and LTVs, to the safety standards.

Lap/shoulder belts would eventually replace lap belts in all but the front center seat position. We consider lap/shoulder belts like all other technologies in this analysis, with voluntary and attributable decisions based on the NPRM baseline. The initial State laws before NHTSA was established did not require lap/shoulder belts.

For some model years there is a mixture of lap belts and lap/shoulder belts provided at the same seating position for different make/models. In this case, the lap belt costs are attributable and assigned to the percentage of the fleet in which they were installed; the lap/shoulder belts may be voluntary or attributable and are assigned to the percentage of the fleet in which lap/shoulder belts were installed. When lap/shoulder belts are voluntary, we assign the cost of lap belts as being attributable and take the difference between the cost of lap belts and lap/shoulder belts as being voluntary for lap/shoulder belts. Researchers interested in examining a different baseline approach for lap belts can find the costs listed separately in Tables 208-12 to 208-15.

While this first NPRM required lap belts at all seating positions in passenger cars, we address each group of seating positions separately (front outboard seats, front center seat, rear outboard seats, and rear center seats), since subsequent rules did not always cover the same seating positions with the same requirements at the same time.

Seat belts are the basic protection system for all occupants (except children in safety seats installed in the vehicle with tethers and anchors), in most types of crashes, designed to keep occupants within the vehicle and close to their original seating position, provide ride-down by gradually decelerating the occupant as the vehicle deforms and absorbs energy, and, if possible, prevent occupants from contacting harmful interior surfaces or one another. Lap belts for outboard front seat occupants were first offered as options in MY 1956 and have been standard on the outboard front seat of passenger cars since 1965. Shoulder harnesses were added in MY

1968 in passenger cars; modern 3-point lap-shoulder belts became standard in MY 1974. Automatic belts that require no action by the occupant were furnished on a small percentage of cars starting in MY 1975, increased from 6.6 percent in MY 1987 to a high of 41.1 percent in MY 1991, but had been phased out by MY 1997.

Overview of regulatory history:

FMVSS Nos. 208, 209, and 210 were among NHTSA's initial safety standards, with an NPRM in December 1966, a final rule in February 1967, and an effective date of January 1, 1968, for passenger cars. FMVSS No. 208 originally required lap belts at each designated seating position in passenger cars only, plus shoulder belts at the outboard front seats if lap belts alone could not prevent dummies from contacting the windshield header in static tests. Since lap belts alone could not prevent dummies from contacting the windshield in static tests, the final rule, in effect, required the front outboard seat of new passenger cars to be equipped with shoulder belts effective January 1, 1968.

NHTSA extended the original FMVSS No. 208 requirements to LTVs up to 10,000 pounds GVWR, effective July 1, 1971. The extension did not result in much immediate change, because most LTV make-models had been equipped with lap belts by 1968 or earlier and continued to have only lap belts up to the mid-1970s.[101]

Responding to (1) the inadequate restraint provided by lap belts alone for the head and torso, (2) the inadequate restraint provided by loosely worn belts and (3) low belt use, NHTSA amended FMVSS No. 208, effective January 1, 1972[102]:

- To require shoulder belts at the outboard front seats of all passenger cars (dropping the test of contact with the windshield header). Shoulder belts at that time could still be separate or integral with the lap belt.
- To require emergency-locking or automatic-locking retractors.
- To require a warning to sound when the lap belts at the outboard front seats were not buckled.
- To permit an automatic restraint system, such as air bags or automatic belts, as an alternative to the manual shoulder belt and the buzzer.
- To include, for the first time, a 30 mph frontal barrier test (in which manual belts must remain intact, and optional automatic systems must meet dummy injury criteria).

Responding to (1) very low use of the separate shoulder belt and (2) continued low use of lap belts, NHTSA amended FMVSS No. 208, effective September 1, 1973, to require[103]:

- Integral, 3-point lap-shoulder belts at the outboard front seats of passenger cars (or, alternatively, automatic protection), and
- Ignition interlocks whereby belts at the outboard front seats must be buckled before a car can be started.

[101] *Federal Register* 35 (September 30, 1970): 15222.
[102] *Federal Register* 36 (March 10, 1971): 4600; 49 CFR, Part 571.208 S4.1.1.
[103] *Federal Register* 38 (June 20, 1973): 16072; 49 CFR, Part 571.208 S4.1.2.

NHTSA amended FMVSS No. 208, effective October 29, 1974, to delete the ignition-interlock requirement. Taking its place was a 4-to-8 second visible and audible warning if the driver was unbelted.[104]

As part of its effort to bring safety requirements for LTVs up to the same level as cars, NHTSA amended FMVSS No. 208 to require integral, 3-point lap-shoulder belts (or, alternatively, automatic protection) at the outboard front seats of most LTVs effective January 1, 1976, and all LTVs with GVWR of 10,000 pounds or less effective September 1, 1981.[105]

Low use of manual belts continued into the early 1980s. On July 17, 1984, NHTSA amended FMVSS No. 208 to phase-in automatic protection, such as air bags or automatic belts, into the outboard front seats of passenger cars between September 1, 1986, and September 1, 1989. To encourage the development of air bags, NHTSA exempted the right front seat from the automatic protection requirement until August 31, 1993, in cars with driver air bags. NHTSA, the manufacturers and the safety community dedicated themselves to a successful effort to encourage buckle-up laws in the States. Comfort and convenience standards for belts were also added to FMVSS No. 208, effective September 1, 1986. During the implementation of automatic protection, automatic belts in passenger cars initially predominated, then driver air bags with manual 3-point belts, and, after September 1, 1993, dual air bags with manual 3-point belts.[106]

The superior protection of lap-shoulder belts, as compared to lap belts alone, was extended to the outboard rear seats. Passenger cars had to have 3-point belts, effective December 11, 1989, and LTVs, starting September 1, 1991.[107] Lap-shoulder belts were extended to all rear designated seating positions for passenger cars and LTVs, including the rear middle seats, but excluding side-facing seats, effective September 1, 2005.[108] The center front seats may be equipped with lap belts or lap/shoulder belts.

Automatic protection was to be phased into the outboard front seats of LTVs with GVWR 8,500 pounds or less from September 1, 1994, to September 1, 1997. Manufacturers used air bags with manual belts in LTVs; none had automatic belts after September 1, 1994, and very few LTVs had automatic belts before that date.[109] On-the-road experience and consumer reaction soon demonstrated that the combination of manual 3-point belts with air bags was the most effective and desirable system. All passenger cars manufactured after September 1, 1997, and all LTVs after September 1, 1998, were required to have manual 3-point belts and air bags for the driver and the right front passenger. Automatic belts were phased out in the front outboard seats.[110] Air bags of the early 1990s presented risks to infants, children under the age of 12, and certain

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[104] *Federal Register* 39 (October 31, 1974): 38380, 39 (December 6, 1974): 42692.
[105] *Federal Register* 40 (July 9, 1975): 28805; 49 CFR, Part 571.208 S4.2.1.
[106] *Federal Register* 46 (January 8, 1981): 2064, 49 (July 17, 1984): 28962, 50 (August 23, 1985): 34152; 49 CFR, Parts 571.208 S4.1.3, 4.1.4 and S7.4
[107] From December 11, 1989, to August 31, 1990, cars were allowed separate lap and shoulder belts as an alternative to 3-point belts, but nobody exercised that option; *Federal Register* 54 (June 14, 1989): 25275, 54 (November 2, 1989): 46257; 49 CFR, Parts 571.208 S4.1.4.2 and S4.2.4. The requirement does not apply to some types of seats/vehicles.
[108] *Federal Register* 68 (December 8, 2004): 70904.
[109] *Federal Register* 56 (March 26, 1991): 12472; 49 CFR, Part 571.208 S4.2.5.
[110] *Federal Register* 58 (September 2, 1993): 46551; 49 CFR, Part 571.208 S4.1.5.3 and S4.2.6.2.

other individuals, particularly when they were too close to the air bag at the time of deployment. NHTSA urged that high-risk individuals travel in the rear seat when possible. NHTSA also amended FMVSS No. 208 with measures to reduce risk when these people must travel in the front seat:

- Effective June 22, 1995, NHTSA permitted manual on-off switches for the passenger air bag in pickup trucks without rear seats or other vehicles that cannot accommodate child safety seats in the rear seat. This provision was implemented with a provision to sunset by September 1, 2012. This facilitated the implementation of passenger air bags in pickup trucks. Effective January 19, 1998, NHTSA also enabled people who must transport high-risk individuals in the front seats of any vehicle to obtain aftermarket on-off switches at their own expense.[111] Although this provision was also implemented with the same sunset date, NHTSA extended the date by 3 years to provide time for consideration of a rulemaking to permanently allow the aftermarket switches.
- Effective March 19, 1997, NHTSA temporarily relaxed some aspects of the frontal impact test in order to facilitate the introduction of redesigned air bags that deploy less forcefully.[112]

From September 1, 2003, to September 1, 2006, advanced air bags were phased in that do not deploy at all (suppression) if a small child is present or deploy only at a low level of force (low-risk deployment) if a small child is present or if an older child/small adult is out-of-position and close to the air bag.[113]

The following technologies have been employed over the years to meet the requirements of FMVSS No. 208:

- **Manual belts** are seat belts that will provide protection in a crash if occupants buckle up. Manual belts can be lap belts that fit around the pelvic region or combined/separate lap and shoulder belts. Manual lap/shoulder belts are now equipped with inertia reels that allow the belt webbing to play out so that the occupant can reach forward freely in the occupant compartment under normal conditions, but lock the belt in place in a crash. To remind drivers to use their belts, FMVSS No. 208 requires the installation of a brief (4-8 seconds) audible and visible driver seat belt warning system. However, many manufacturers are now extending the duration of the audible and visible reminders and providing them for passenger seats in an attempt to get more occupants to fasten their seat belt. The following are types of manual belts:
    - Manual lap belts with manual adjustment (airline style), simple retractors, or locking retractors

[111] *Federal Register* 60 (May 23, 1995): 27233, 62 (November 21, 1997): 62406; 49 CFR, Part 571.208 S4.5.4 and Part 595.
[112] *Federal Register* 62 (March 19, 1997): 12960; 49 CFR, Part 571.208 S13.
[113] *Federal Register* 65 (May 12, 2000): 30679; 49 CFR, Part 571.208 S14.

  - Separate manual lap belts and shoulder harnesses, with manual adjustment or simple retractors on the lap belt, and manual adjustment on the shoulder harness
  - Manual 3-point belts, combining the lap belt and shoulder harness into a single integral device, with locking retractors

- **Automatic belts** are similar in many respects to manual belts but differ in that they are attached at one end between the seats in a passenger car without a center front seat and at the other end to the interior of the door, or in the case of a belt with a motorized anchorage, to the doorframe. The belt moves out of the way when the door is opened and automatically moves into place around the occupant when the door is closed. Thus, the occupant need take no action to gain the protective benefits of the belt. The following are types of automatic belts:

  - Motorized torso belts with manual lap belts,
  - Non-motorized automatic torso belts with manual lap belts and/or knee bolsters, and
  - Door-mounted, automatic 3-point belts.

- **Frontal air bags** are fabric cushions that are very rapidly filled with gas to cushion the occupants against colliding with the vehicle interior when a crash occurs that has a frontal deceleration strong enough to register on a sensor device in the vehicle. When such a crash is sensed, there is rapid generation or release of gas to inflate the bag. After the crash, the bag quickly deflates to permit emergency egress. Beginning in 1996, other types of air bags such as side air bags or window curtains have been installed, but FMVSS No. 208 regulates only frontal air bags. Frontal air bags are broken down into two categories:

  - Driver air bags, and
  - Dual air bags (driver and right-front passenger).

The weight and consumer cost of the various seat belt systems, along with seat belt assembly anchorages, and frontal air bags in passenger cars were studied and are presented in the following sections.

Passenger Car Studies – Seat Belts

Manual Front Outboard Seat Belts Without Retractors. Passenger cars employed lap belts as the occupant protection system for many years prior to the implementation of FMVSS No. 208. Seat belt systems prior to 1968 were manually adjusted, airline style. Manual lap belts were believed to be highly effective not only for preventing occupant ejection from the vehicle in crashes but also for preventing harmful occupant contacts with interior vehicle components. They were installed initially at the outboard front seating positions.

Crash investigation and biomechanics research demonstrated that a lap belt alone was insufficient for restraining an occupant's head and upper torso from injurious contact with the vehicle's interior, especially in frontal crashes, and might even result in a harmful concentration of force on the abdomen. A shoulder harness was needed in addition to the lap belt to limit the forward motion of the upper body.

The original FMVSS No. 208 required for passenger cars a lap (Type 1) seat belt at all designated seating positions and a lap and shoulder belt at the outboard front seating positions if the windshield header was a potential head impact area for a lap-belted dummy. Since it was uncertain that a lap belt could always keep the dummy from contacting the windshield header in the static test, this rule in effect led to the installation of lap and shoulder belts for the front outboard seat of passenger cars. The final rule was published in the Federal Register on February 3, 1967, (32 FR 2414). The NPRM was published in the Federal Register on December 3, 1966 (31 FR 15212), making the baseline date for lap belts at all positions and the baseline date for lap and shoulder belts for front outboard positions September 1, 1966, or MY 1967. By MY 1967, all passenger cars had either a lap belt (99.35%) or an integral lap/shoulder belt (0.65%) at the front outboard positions. We know of no models that had a lap and separate shoulder belt in MY 1967. As discussed above, NHTSA has decided to consider all lap belts as being attributable to the safety standards. The lap/shoulder belt installations from MY 1967 of 0.65 percent of passenger cars is considered voluntary, and the voluntary percentage is held at that MY 1967 baseline level through MY 2012. FMVSS No. 208 in effect required lap and shoulder belts beginning January 1, 1968. Since the model year starts September 1, 1967, some models were delayed installing the shoulder harness until January 1, 1968. Without any actual data on the split between lap belts and lap and shoulder belts, for this analysis we assume that 12.5 percent of all MY 1968 passenger cars came equipped with lap belts and 87.5 percent of all MY 1968 passenger cars came equipped with lap and shoulder belts for the front outboard seats.[114]

Crash data and observational surveys soon indicated that few occupants fastened both belts, and most did not bother using the shoulder harness. These seat belts were manually adjustable. This shortcoming was remedied with the development of integral 3-point (Type 2) belts, which were used primarily by the European manufacturers. The integral 3-point belts became, and are still today, the primary component of the occupant protection system. They are highly effective in saving lives and preventing serious injuries in rollovers, frontal crashes, and many types of side impacts.

A cost and weight analysis was performed on three lap belt systems and one separate lap/shoulder belt without retractors.[115] NHTSA did not cost-analyze any of the early European integral 3-point belt systems, which were present in a small percentage of new cars in the United States. They are assumed to have approximately the same weight and consumer cost as the early separate lap/shoulder belts. Since the lap belt systems studied ranged over several

[114] Lap and shoulder belts were required January 1, 1968. Therefore, there are 3 months (Oct., Nov., and Dec). of unknown belt installations. We assumed for these 3 months that half of the passenger cars would be equipped with lap belts and half with lap and shoulder belts. Thus, lap belts are assumed to be installed in half the fleet for 1/4 of the year (1/4 * 0.5 = 1/8 of the year or 12.5%).

[115] McLean, R. F., Eckel, C. E., & Cowan, D. (1978, October). *Cost evaluation of four Federal Motor Vehicle Standards, Volume I* (Report No. DOT HS 803 871). Washington, DC: National Highway Traffic Safety Administration, Docket No. 2011-0066-0082.

model years, we took the arithmetic average of their weights and costs. With very little data on separate lap/shoulder belt systems and 3-point belt systems without retractors, we combined these estimates and used their average weight and cost for both systems.

A cost and weight analysis was also performed on seat belt assembly anchorages in passenger cars.[116] Table 208-1 shows the average weight and consumer cost per seat for the manual front outboard seat belts without retractors, plus the seat belt assembly anchorages. For front outboard lap/shoulder belts, $27.91 was used from 1968 to 1971 (see discussion later).

TABLE 208-1
AVERAGE WEIGHT AND CONSUMER COST PER SEAT OF MANUAL FRONT OUTBOARD SEAT BELTS WITHOUT RETRACTORS IN PASSENGER CARS

BELT ASSEMBLIES	WEIGHT IN POUNDS	CONSUMER COST ($2012)
Lap Belt Only	2.38	$25.91
Separate Lap/Shoulder Belt	2.95	$27.91
3-Point Belt	2.95	$27.91

Manual Front Outboard Seat Belts With Retractors. Manually adjusting the belt systems was considered inconvenient, especially when people of different sizes took turns driving the same car. The belt was not adjusted to fit the size of the person driving, which in many cases resulted in a loose-fitting belt making it less effective. In order to eliminate the loose fit and the inconvenience of manual adjustment, retractors were added to the seat belt systems. Retractors are a device for storing part or all of the webbing in a seat belt assembly. However, with automatic locking retractors the belts became uncomfortably tight and restricted the freedom of motion needed for driving. A major improvement was the inertia reel or emergency locking retractor. It allowed the belt to spool out freely and retract when an occupant moved forward and backward in the seat during normal vehicle operation, but it locked the belt in place upon sensing a crash by sensing rapid belt spool out or vehicle deceleration.

The final rule amending FMVSS No. 208 to require integral 3-point belts at front outboard seats in passenger cars was published in the Federal Register on June 20, 1973, (38 FR 16072). The NPRM was published in the Federal Register on April 30, 1973, (38 FR 9830), making the baseline date September 1, 1972, or MY 1973. Since 100 percent of the fleet had a lap belt with a retractor and a separate shoulder belt or a lap/shoulder belt with a retractor by MY 1973, the increased cost of retractors is considered voluntary from their introduction in MY 1972 to MY 2012.

To summarize the cost estimate methodology for lap/shoulder belts in the front outboard seats of passenger cars:

For MY 1968 to MY 1971, lap/shoulder belts without retractors were installed in the front outboard seats of passenger cars. The cost can be subdivided into two components: (1) the cost of a lap belt alone and (2) the incremental costs for lap/shoulder belts over lap belts only. The

[116] Osen & Ludtke, DOT HS 806 772, 1985.

first component is always attributable. The second component is attributable for 99.35 percent of the fleet and voluntary for 0.65 percent of the fleet.

For MY 1972 and later (lap/shoulder belts with retractors) the cost includes three components: (1) the cost of a lap belt alone, (2) the incremental costs for lap/shoulder belts over lap belts only, and (3) the incremental cost of retractors. The first component is always attributable. The second component is attributable for 99.35 percent of the fleet and voluntary for 0.65 percent of the fleet. The third component is always voluntary because all cars were already equipped with retractors in the baseline year. [117] [118]

Beginning in January 1972, FMVSS No. 208 offered three options to meet its requirements for an occupant restraint system.[119]

- **Option 1 –** Meet the injury protection criteria of the standard by automatic means in frontal and front angular crash test, or provide either (1) automatic crash protection in a lateral and rollover crash test or (2) manual lap belt or combination of a manual lap/shoulder belt at each seating position.

- **Option 2 –** Meet the injury protection criteria of the standard by automatic means in a frontal crash test, and provide a manual lap belt or a combination of a manual lap/shoulder belt for each seating position.

- **Option 3 –** Provide, at each front outboard-designated seating position, a Type 2 belt (a lap and shoulder belt) and at other seating positions either a Type 1 (lap belt) or Type 2 belt.

In addition, each belt system must have a belt warning system that operates a continuous or flashing light and a buzzer for 4-8 seconds when the car is started and the driver's belt is not

[117] An example calculation for costs for MY 1980 for passenger cars for front outboard lap/shoulder belts that appears in Table 208-16c is: 2 seats * $45.06 * 0.9944 with manual belts = $89.62 for lap/shoulder belts. To estimate the voluntary costs, you start with the lap/shoulder belt costs for 2 belts of $55.82 minus information from 1968, the last year of lap belts in the front outboard seat, lap belt cost were $$51.82 times the percentage of the fleet (0.9944) that has lap/shoulder belts times the voluntary percentage of 0.0065. Added to that is the voluntary costs of retractors, estimated to be ($45.18 for a lap/shoulder belt with retractors minus $27.91 for a lap/shoulder belt without retractors times 2 belts times the percentage of the fleet that had lap/shoulder belts (0.9944). Attributable costs were estimated to be the difference between total costs and voluntary costs. Thus, the estimated voluntary lap/shoulder belt costs of $34.27 for MY 1980 are calculated as ($55.82-$51.82)*0.9944*.0065 + ($45.18-$27.91)*2*0.9944.

[118] Several methods were examined to determine voluntary versus attributable accounting for lap/shoulder belts, given that lap belt costs were determined by NHTSA to be attributable and would be considered as an attributable part of the lap/shoulder belt costs. Holding lap belt costs constant through MY 2012 would not work because lap/shoulder belts costs were on a learning curve and eventually lap/shoulder belt costs would be less than lap belt costs. We considered developing a learning curve for lap belts, but the learning curve for lap belts would be different than the learning curve for lap/shoulder belts and eventually this would lead to unlikely results. The best solution was to relate the post-learning curve lap/shoulder belt costs to the pre-learning curve lap/shoulder belt costs. In this way when the lap/shoulder belt costs decreased for the learning curve, the voluntary and attributable lap/shoulder belt costs also decreased.

[119] *Federal Register*, Vol. 36, No. 47, pg. 4600.

used.[120] All belts must have an emergency release mechanism that is readily accessible to an occupant. Manual belts must be equipped with a push button release.

Vehicle manufacturers chose the third option by employing Type 2 belts in the front outboard positions and Type 1 belts in the other positions. The domestic and Japanese manufacturers kept the lap and separate shoulder belt for the front outboard positions and added retractors. The European manufacturers stayed with the integral lap/shoulder belts for the front outboard positions and added retractors.

The number of separate lap/shoulder belts and integral 3-point belts with and without retractors in MY 1968 to MY 1973 are shown in Table 208-2 by model year.[121] Retractors were required January 1, 1972. Since the model year starts October 1, 1971, we don't know how many vehicles produced between October 1, 1971, and December 31, 1971, came equipped with retractors. For this analysis, we assumed that half of these vehicles in this 3-month period were equipped with retractors and half were not. Thus, the estimated percentage of MY 1972 passenger cars not equipped with retractors equals one-quarter of the fleet times half or one-eighth of the fleet or 12.5 percent. This means that an estimated 87.5 percent of the MY 1972 passenger cars had retractors in the lap/shoulder belts for outboard seats.

Table 208-2
Percentage of Lap/Shoulder Belts
By Belt Type for Outboard Front Seating Positions
In MY 1968 to MY 1973 Passenger Cars

	MY 1968	MY 1969	MY 1970	MY 1971	MY 1972	MY 1973
Lap Belts	12.5					
Without Retractor						
Separate Lap/Sh.	73.3	72.3	72.9	72.3	9.3	
Integral 3-point	14.2	27.7	27.1	27.7	3.2	
With Retractor						
Separate Lap/Sh.					65.2	74.2
Integral 3-point					22.3	25.8

[120] From January 1, 1972, to August 31, 1973, a continuous light and buzzer were required. From September 1, 1973, to October 29, 1974, an ignition interlock system was required, whereby front outboard belts had to be buckled before a car could be started. The ignition interlock requirement was revoked on October 29, 1974, and the 4-8 second warning system replaced the persistent warning system. We did not obtain a cost estimate for the ignition interlock system.

[121] The percentages in Table 208-2 were derived from Appendix C of the January 2015 Kahane report *Lives Saved by Vehicle Safety Technologies and Associated Federal Motor Vehicle Safety Standards, 1960 to 2012 (Report No.*DOT HS 812 069). The percentages in Table C-1 for passenger car front outboard lap belts, actually includes both lap belts and separate lap and shoulder belts, while the percentages for outboard front 3-point belts includes integral 3-point belts.

Starting with MY 1974, the separate shoulder belt was no longer allowed for the front outboard seating positions under the third option. Only an integral lap/shoulder belt was allowed.[122] By MY 1978, features like dual retractors (one for the lap belt and one for the torso belt) were introduced to improve the ease-of-use and performance of front seat belts.

A series of cost and weight analyses were performed on two separate lap/shoulder belts and 20 integral 3-point seat belts used to satisfy the third option in FMVSS No. 208.[123] [124] [125] [126]

Table 208-3 shows the arithmetic average weight and consumer cost per seat for the manual front outboard seat belts with retractors. The lap belt estimates were derived by subtracting 0.29 pounds and $1.68 from the separate lap/shoulder belt estimates. A similar method was used for LTVs.

For front seat outboard lap/shoulder belts costs, $27.91 was used for 1968 to 1971, $40.02 was used for 1972 and 1973 for separate lap/shoulder belts, then for integral 3-point belts with retractors $45.18 is used for 1972 to 1978 (with 1972 and 1973 being distributed as shown in Table 208-2), $45.06 for 1979 to 1981, $39.11 for 1988 to 1996 and then the learning curve is applied for 1997 to 2012. Thus, we used the teardown data where available and the learning curve after that point.

TABLE 208-3
AVERAGE WEIGHT AND CONSUMER COST PER SEAT OF MANUAL FRONT OUTBOARD SEAT BELTS WITH RETRACTORS IN PASSENGER CARS

MODEL YEAR	WEIGHT IN POUNDS	CONSUMER COST ($2012)
Lap Belt		
1972-1973	4.23	$38.34
Separate Lap/Shoulder Belt		
1972-1973	4.52	$40.02
Integral 3-Point Belt		
1972-1974	4.60	$45.18
1979-1981	5.82	$45.06
1988-1996	3.97	$39.11

[122] Under the first two options, a Type 1 belt was permissible if the vehicle could meet the frontal crash test requirement.
[123] McLean, Eckel, & Cowan, 1978, Docket No. 2011-0066-0082.
[124] Gladstone, Harvey & Lesczhik, 1982, Docket No. 2011-0066-0066.
[125] Fladmark, G. L., & Khadilkar, A. V. (1992, September). *Cost estimates of manual & automatic crash protection systems (CPs) in selected 1988-1992 model year passenger cars brake systems, volumes I-IV* (Report Nos. DOT HS 807 949, 807 950, 807 951 & 807 952) Washington, DC: National Highway Traffic Safety Administration, Docket No. 2011-0066-0030, 0031, 0032, and 0036.
[126] Fladmark, G. L., & Khadilkar, A. V. (1996, September). *Cost estimates of (1) side impact crash protection of 1994-95 vs. 1993-94 model year passenger cars; (2) Automatic crash protection of 1995 model year pickup trucks, vans, and multipurpose passenger vehicles; and (3) Automatic crash protection of two 1996 model year passenger cars, volume I and volume II* (Report Nos. DOT HS 809 798, DOT HS 809 799, DOT HS 809 801. & DOT HS 809 802) Washington, DC: National Highway Traffic Safety Administration, Docket No. 2011-0066-0024, 0023, 0021 and 0020.

The sample of integral 3-point seat belts represented different eras in passenger cars. This information ($45.18 for 1974 and $39.11 for 1992) was used to determine a progress rate for the learning curve. Sales for the learning curve calculations were accumulated starting in 1974 with integral 3-point belts, and the learning curve costs were fit so that they pass through $39.11 in 1992, which was the average year of the 14 teardowns completed on MY 1988 to MY 1996 passenger cars.

The weight of lap/shoulder belts starts at 2.95 pounds for 1968 to 1971 without retractors (Table 208-1), increases to 4.52 pounds for separate lap/shoulder belts with retractors in 1972-73, integral 3-point belts for front outboard seating positions in passenger cars is estimated based on the teardown studies, starting with 4.60 pounds for MY 1974, increasing linearly to 5.82 pounds in MY 1979, then decreasing starting in MY 1982 linearly to 3.97 pounds in MY 1988 and staying at that level through 2012 .

Rear Outboard Seat Belts. The February 3, 1967, (32 FR 2414) final rule required lap belts at all designated seating positions for passenger cars, including rear outboard seats. The NPRM was published in the Federal Register on December 3, 1966, (31 FR 15212), making the baseline September 1, 1966, or MY 1967. As discussed above, all lap belts are considered attributable to the safety standards.

From January 1, 1968, to December 10, 1989, FMVSS No. 208 only required Type 1 (lap) belts at the rear-outboard positions of passenger cars. In MYs 1966-1970, 100 percent of rear-outboard seats were equipped with Type 1 belts. Type 2 belts, which were integral 3-point belts were voluntarily installed in a small number of European make-models starting in 1971, and subsequently in a gradually increasing list of models. Retractors were added in 1972.

Three-point belts are more effective than lap belts, particularly in frontal crashes, because they restrain the torso. Lap/shoulder belts are highly effective in saving lives and preventing serious injuries in rollovers, frontal crashes, and many types of side impacts. On June 14, 1989, (54 FR 25275), NHTSA published a final rule in the Federal Register amending FMVSS No. 208 to require 3-point belts at the rear outboard seats of passenger cars. The NPRM was published in the Federal Register on November 29, 1988, (53 FR 47982), making the baseline date September 1, 1988, or MY 1989. Since 100 percent of the fleet did not have 3-point belts in the rear outboard seats of passenger cars by the baseline date, 3-point belts in the rear outboard seats of passenger cars would have all been considered voluntary through MY 1989 and the voluntary percentage (67.67%) would have been held at that MY 1989 baseline level through MY 2012. However, attributable costs will be the cost of lap belts through MY 1989 and then for MY 1990 to MY 2012, what the cost of lap belts would have been plus the incremental cost for lap/shoulder belts over lap belts times the difference between the installation rate for MY 1990 (100%) to MY 2012 minus the voluntary baseline level of MY 1989.[127] The final rule mandating

[127] An example calculation for costs for MY 1985 for passenger cars that appears in Table 208-17c for rear outboard lap/shoulder belts is: 1.96 seats per car * $25.90 learning curve cost per belt = $50.76 * 0.0575 cars with rear manual lap/shoulder belts = $2.92 for lap/shoulder belts. To estimate the attributable costs you take the lap belt costs for MY 1985 after applying the 1.96 seats per car and the learning curve of $44.87 divided by the lap/shoulder belt cost times the total cost or $44.87/$50.76*2.92 = $2.58. For MY 1995, you start with the information from 1989, the last year of lap belts in the rear outboard seat, after applying 1.96 seats and the learning curve to both, lap belt cost were $44.41 divided by lap/shoulder belt costs of $46.16 times MY 1995 total costs of $41.56. Thus, the estimated

lap/shoulder belts for forward-facing rear outboard seating positions took effect December 11, 1989, in all passenger cars, other than convertibles, with a GVWR of 10,000 pounds or less, and then it took effect for convertibles on September 1, 1991.

A series of cost and weight analyses were performed on rear outboard seat belts with and without retractors.[128] [129] Table 208-4 shows the average weight and consumer cost per seat for the rear outboard seat belts.

TABLE 208-4
AVERAGE WEIGHT AND CONSUMER COST PER SEAT OF REAR OUTBOARD SEAT BELTS IN PASSENGER CARS

BELT ASSEMBLIES	WEIGHT IN POUNDS	CONSUMER COST ($2012)
Without Retractors		
Lap Only (1968)	1.83	$20.31
3-Point Belt (1971)	1.83	$20.31
With Retractors		
Lap Only (1972-1974)	2.73	$22.58
Lap Only (1979-1981)	3.09	$32.66
Lap Only (1988-1989)	2.84	$23.96
Lap Only Average (1972-74 & 1988-89)	2.79	$23.27
3-Point Belt (1988-1992)	2.58	$22.74

Note: In these small tables for FMVSS 208, the dates in the first column by the types of seat belts relate to the model years of the vehicles in the teardown study, not the year that the data was applied in the analysis.

The sample of the lap-only seat belts represented three different eras in passenger cars. The average weight and consumer costs of the 1972-1974 samples and the 1988-1989 samples are nearly equal. There is no obvious explanation why the 1979-1981 costs are substantially higher, in fact, even higher than the cost estimate for 3-point belts. It is perhaps a consequence of the specific make-models selected. At all the other seat positions, the 1979-1981 estimates were consistent with the earlier and later estimates. For rear outboard lap belts we use $20.31 and 1.83 pounds from 1968 to 1971, then we assume for 1972 to 1989, an average cost derived across all lap belt with retractor studies for the average MY 1980 vehicle of $23.27 for the learning curve and 2.79 pounds.

For rear outboard lap/shoulder belts, NHTSA did not cost analyze any of the early European integral 3-point belt systems in MY 1971 without retractors, which were present in fewer than one percent of new cars in the United States. They are assumed to have approximately the same weight and consumer cost as the lap belt only. For rear outboard lap/shoulder belts with retractors we took the results from the Fladmark study (DOT HS 807 952) of 4 belt systems from

lap belt attributable part of the equation for MY 1995 would have been $44.41/$46.16*41.56 = $39.98. The incremental costs for lap/shoulder belts being applied to a larger percentage of the fleet is calculated as 0.3233 times ($41.56 - $44.41/$46.16*$41.56) = $0.51, for a total of $40.49 ($39.98 + $0.51).

[128] McLean, Eckel, & Cowan, 1978, Docket No. 2011-0066-0082.
[129] Fladmark & Khadilkar, 1992, Docket No. 2011-0066-0030.

MY 1988 to MY 1992 (average MY 1990) that averaged $22.74 and 2.58 pounds. From MY 1972 to MY 2012 we applied the learning curve for costs with a base of $22.74 for the MY 1990 vehicles. This average cost is slightly less than the average cost estimate for rear seat outboard lap belts with retractors ($23.27), which suggests that there are differences in the models selected for teardowns because lap/shoulder belts should cost more than lap belts, but we are using the data available.

Front and Rear Center Seat Belts. From January 1, 1968, to 2003, FMVSS No. 208 has only required Type 1 (lap) belts at the front and rear center seat positions. They are airline-style belts without retractors. The final rule was published in the Federal Register on February 3, 1967, (32 FR 2414), required lap belts at all designated seating positions (which included the front and rear center seats) for passenger cars. The NPRM was published in the Federal Register on December 3, 1966, (31 FR 15212), making the baseline date September 1, 1966, or MY 1967. However, as discussed above, NHTSA has decided to consider all lap belts as being attributable to the safety standards.

On December 8, 2004, (69 FR 70904), in response to Anton's Law, signed on December 4, 2002, NHTSA published a final rule mandating lap/shoulder belts for all forward-facing rear seating positions, including center seats, and all rear facing seating positions (the back of the station wagon style), in all motor vehicles with GVWR of less than 10,000 pounds (all passenger cars and LTVs). The NPRM was published in the Federal Register on August 6, 2003, (68 FR 46546), making the baseline date September 1, 2002, or MY 2003.

The phase-in effective dates are:

- 50 percent of all vehicles manufactured from September 1, 2005, to August 31, 2006;
- 80 percent of all vehicles manufactured from September 1, 2006, to August 31, 2007; and
- 100 percent of all vehicles manufactured on or after September 1, 2007, must comply.

In the 1990s manufacturers began voluntarily installing lap/shoulder belts in the rear center seating position. By MY 1999, over 30 percent of passenger cars were equipped with rear center lap/shoulder belts and this increased to 82 percent by the baseline date of MY 2003. Since 100 percent of the fleet did not have 3-point belts in the rear center seats of passenger cars by the baseline date, 3-point belts in the rear center seats of passenger cars would have all been considered voluntary through MY 2003 and the voluntary percentage (82.13%) would have been held at that MY 2003 baseline level through MY 2012. However, attributable costs will be the cost of lap belts through MY 2003 and then for MY 2004 to MY 2012, what the cost of lap belts would have been plus the incremental cost for lap/shoulder belts over lap belts times the difference between the installation rate for MY 2004 to MY 2012 minus the voluntary baseline level of MY 2003.

A series of cost and weight analyses were performed on front and rear center lap belts.[130,131,132] Table 208-5 shows the average weight and consumer cost per seat for the front and rear center belts.

TABLE 208-5 AVERAGE WEIGHT AND CONSUMER COST PER SEAT OF FRONT AND REAR CENTER LAP BELTS WITHOUT RETRACTORS IN PASSENGER CARS		
BELT ASSEMBLIES	**WEIGHT IN POUNDS**	**CONSUMER COST ($2012)**
Front Center		
Lap Only (1968-1974)	0.90	$17.80
Lap Only (1979-1981)	0.79	$16.48
Rear Center		
Lap Only (1968-1974)	1.02	$17.41
Lap Only (1979-1981)	0.75	$15.38
Lap Only (1992-1993)	1.09	$14.00

There is a decrease in cost over time in Table 208-5. The $16.48 for MY 1980 for the front center lap belt and $14.00 for MY 1992 for the rear center lap belt are used in the learning curve. The weights used for the front center lap belts were 0.90 pounds from MY 1968 to MY 1974, decreasing by 0.02 pounds per year from MY 1975 to MY 1978, and then 0.79 pounds for MY 1979 and thereafter. The weights used for the rear center lap belts were 1.02 pounds from MY 1968 to MY 1974, decreasing by 0.054 pounds per year from MY 1975 to MY 1978, 0.75 pounds for MY 1979 to MY 1981, increasing by 0.03 pounds per year from MY 1982 to MY 1991, then 1.09 pounds for MY 1992 and thereafter.

The consumer cost estimate of rear center 3-point seat belts of 3.03 pounds and $36.55 in 2012 dollars was calculated in the Final Economic Assessment[133] on adding lap/shoulder belts to the center seats of passenger cars and LTVs and was based partly on the teardown of three existing systems.[134] The $36.55 cost estimate was based on MY 1996 vehicles and learning was applied from MY 1994 to MY 2012.

[130] McLean, Eckel, & Cowan, 1978), Docket No. 2011-0066-0082.
[131] Gladstone, Harvey & Lesczhik1982), Docket No. 2011-0066-0066.
[132] Khadilkar, A. V., Fladmark, G. L., and Khadilkar, J. (2001, January). *Teardown cost estimates of automotive equipment manufactured to comply with Motor Vehicle Standards, FMVSS 208 – Occupant protection, Volume II* (Report No. DOT HS 809 807). Washington, DC: National Highway Traffic Safety Administration, Docket No. 2011-0066-0016.
[133] NHTSA. (2004). *Final Economic Assessment and Final Regulatory Flexibility Analysis, Costs of Putting a Shoulder Belt in the Center Seats of Passenger Cars and LTVs*. Washington, DC: Author. In Docket No. 2004-18726-0002.
[134] Ibid.

Automatic Front Outboard Seat Belts With Retractors. On July 5, 1977, (42 FR 34289), a final rule was published in the Federal Register requiring automatic occupant protection at front outboard seats in passenger cars. However, that final rule was rescinded in 1981 before its effective date. This analysis uses as a baseline the final rule that did result in automatic protection being implemented. The July 17, 1984, (49 FR 28962), final rule amended FMVSS No. 208 to require automatic occupant protection at front outboard seats in passenger cars. The NPRM was published in the Federal Register on October 14, 1983, (48 FR 48622), making the baseline date September 1, 1983, or MY 1984.

The requirements for automatic restraints in the front seating positions of passenger cars were issued in response to the persistent low use rate of manual belts. Two systems that qualified as automatic restraints were air cushion restraints (air bags) and automatic seat belts (belts that automatically move into place around the occupant when the door is closed).

The 1984 rule required that some type of automatic restraint be installed in passenger cars, but provided the manufacturers the choice of a variety of methods of providing automatic protection, including automatic seat belts and air bags, as long as certain specified performance requirements were met. The final rule required automatic occupant protection in all passenger automobiles based on a phase-in schedule beginning September 1986, with full implementation being required by September 1989. The front center seat of passenger cars was exempt from, and rear seats were not covered by, the requirements.

Since 100 percent of the fleet did not have automatic belts in the front outboard seats of passenger cars by the baseline date, automatic belts would have all been considered voluntary from MY 1975 when they were introduced through MY 1984 and the voluntary percentage (0.33%) would have been held at that MY 1984 baseline level through MY 2012. However, attributable costs will be the cost of lap belts through MY 1984 and then for MY 1985 to MY 1996 (the last year that automatic belts were installed in passenger cars), what the cost of lap belts would have been plus the incremental cost for automatic belts over lap belts times the difference in the installation rate for MY 1985 to MY 1996 minus the voluntary baseline level of MY 1984.

Most vehicle manufacturers initially chose to comply with the requirements by installing automatic belts in many of their vehicles. The fact that the rule did not include design specifications gave them broad flexibility in selecting the design and performance characteristics of their automatic belts. For example, the motorized two-point torso belts required the occupant to manually fasten the lap belt for full protection, while the door-mounted non-motorized 3-point belts were often detached by occupants from their anchorage in the middle of the car and subsequently used in the same manner as manual 3-point belts. And, one of the non-motorized 2-point torso belt systems had an automatic shoulder belt used in combination with a knee bolster. This was the only shoulder belt system specifically designed for use without a lap belt because the knee bolster took the place of the lap belt.

A series of cost and weight analyses were performed on automatic motorized and non-motorized seat belts.[135] [136] [137] Table 208-6 shows the average weight and consumer cost per seat for the

[135] McLean, Eckel, & Cowan, 1978.

automatic front outboard seat belts with retractors and anchors. Since these estimates are based on at most nine systems, arithmetic rather than sales-weighted averages of the costs and weights were used.

TABLE 208-6
AVERAGE WEIGHT AND CONSUMER COST PER SEAT OF AUTOMATIC FRONT OUTBOARD SEAT BELTS IN PASSENGER CARS

BELT ASSEMBLIES	WEIGHT IN POUNDS	CONSUMER COST ($2012)
Non-Motorized		
2-point (1975-1984)	11.88	$ 89.12
2-point (1987-1990)	17.72	$158.63
2-point (1991-1995)	5.34	$ 63.06
3-point	15.12	$203.59
Motorized		
2-point	16.01	$224.80

The estimate for 1987-1990 non-motorized 2-point belts is substantially higher than the estimates for the 1975-1984 and 1991-1995 systems primarily because structural modifications were made to the existing vehicle. The costs would probably be lower if the 2-point belts had been built in as an overall redesign of the vehicle like it was in the 1975-1984 and 1991-1995 systems. NHTSA does not know if these extra costs were characteristic of most of the systems in the first years of the automatic protection requirement, or only of the one system we analyzed. Similarly, we do not know if the low cost of the 1991-1995 system relative to 1987-1990 represents typical across-the-board savings as manufacturers gain experience with new technologies, or merely the difference between the two systems we selected for analysis. Likewise, we do not know if the costs for the non-motorized 3-point belts and the motorized 2-point belts, each based on analyses of three 1987 systems, were reduced in subsequent years. Since all automatic belts were phased out by the mid-1990s, NHTSA is not planning any further cost analyses.

Successful enactment of buckle-up laws in most of the States, and the demonstrated superior performance and customer preference for manual 3-point belts with air bags, soon eliminated interest in the various types of automatic belts. FMVSS No. 208 was subsequently modified to require dual air bags plus manual 3-point belts effective September 1, 1997, in passenger cars. In 1986-1996, vehicles equipped with air bags usually had manual belts, but some had automatic belts at one or both of the front outboard positions.

The distribution of automatic belts used in the cost calculation is shown in Tables 208-7a, 208-7b, and 208-7c. These tables show the average number of automatic belts by model year. Tables 208-7a and 208-7b show the average cost for each of the automatic belt types, while Table 208-7c shows the average weight by automatic belt types. These costs and weights are weighted by the distribution of the number of belts per car for each model year.

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[136] Khadilkar, A. V., Fladmark, G. L. L., & Firth, B. W. (1988, June). *Cost estimates of automatic crash protection in 1987 model year passenger cars – Volumes I-IV* (Report Nos. DOT HS 807 319, 807 320, 807 321, & 807 322.)) Washington, DC: National Highway Traffic Safety Administration, Docket No. 2011-0066-0037 to 0040.
[137] Fladmark & Khadilkar, 1992, Docket No. 2011-0066-0032.

TABLE 208-7a AVERAGE CONSUMER COST BY TYPE OF BELT AND THE NUMBER OF SEAT BELTS BY TYPE IN AN AVERAGE PASSENGER CAR FOR MODEL YEARS 1975-1987								
SEAT BELT ASSEMBLY	**COST PER SEAT**	**n OF BELTS PER CAR**						
		’75 to 81	**‘82**	**‘83**	**‘84**	**‘85**	**‘86**	**‘87**
Automatic								
2-Point Non-Motorized (1975-1984)	$ 89.12	0.01	0.005					
2-Point Non-Motorized (1987-1990)	$158.63							0.013
2-Point Non-Motorized (1991-1995)	$ 63.06							
3-Point Non-Motorized	$203.59							0.052
2-Point Motorized	$224.80	0.01	0.005	0.01	0.01	0.01	0.01	0.065

TABLE 208-7b AVERAGE CONSUMER COST BY TYPE OF BELT AND THE NUMBER OF SEAT BELTS BY TYPE IN AN AVERAGE PASSENGER CAR FOR MODEL YEARS 1988-1994								
SEAT BELT ASSEMBLY	**COST PER SEAT**	**n OF BELTS PER CAR**						
		‘88	**‘89**	**‘90**	**‘91**	**‘92**	**‘93**	**‘94**
Automatic								
2-Point Non-Motorized (1975-1984)	$ 89.12							
2-Point Non-Motorized (1987-1990)	$158.63	0.02	0.01	0.07				
2-Point Non-Motorized (1991-1995)	$ 63.06				0.09	0.09	0.03	0.03
3-Point Non-Motorized	$203.59	0.12	0.18	0.37	0.32	0.24	0.23	0.19
2-Point Motorized	$224.80	0.10	0.13	0.36	0.41	0.23	0.27	0.17

TABLE 208-7c AVERAGE WEIGHT (lb) BY TYPE OF BELT AND THE NUMBER OF SEAT BELTS BY TYPE IN AN AVERAGE PASSENGER CAR FOR MODEL YEARS 1995-2001								
SEAT BELT ASSEMBLY	**WEIGHT PER SEAT**	**n OF BELTS PER CAR**						
		'95	**'96**	**'97**	**'98**	**'99**	**'00**	**'01**
Automatic								
2-Point Non-Motorized (1975-1984)	11.88							
2-Point Non-Motorized (1987-1990)	17.72							
2-Point Non-Motorized (1991-1995)	5.34	0.00						
3-Point Non-Motorized	15.12	0.08	0.03					
2-Point Motorized	16.01	0.05	0.02					

LTV Studies – Seat Belts

Front Outboard Seats

On September 30, 1970, (35 FR 15222), a final rule was published in the Federal Register extending FMVSS No. 208 (lap belts at all designated seating positions) to LTVs. The NPRM was published in the Federal Register on September 20, 1969, (34 FR 14660), making the baseline date September 1, 1969, or MY 1970 for lap belts. However, similar to the discussion for passenger cars provided above, we decided that all lap belts, including lap belts for LTVs, will be considered attributable to the safety standards.

On July 9, 1975, (40 FR 28805), a final rule was published in the Federal Register amending FMVSS No. 208, extending 3-point belts at front outboard seats to LTVs. The NPRM was published on June 3, 1975, (40 FR 23897), making the baseline date September 1, 1974, 1974, or MY 1975 for front outboard lap/shoulder belts for LTVs. Since 100 percent of the fleet did not have lap/shoulder belts in the front outboards seats of LTVs by the baseline date, they would have been considered voluntary through MY 1975 and the voluntary percentage (43.52%) would have been held at that MY 1975 baseline level through MY 2012. However, because of the decision to call lap belt costs attributable, for MY 1968 to MY 1975, the incremental costs for lap/shoulder belts are distributed between being attributable (at the lap belt cost) and voluntary (at the difference in costs between lap belts and lap/shoulder belts). As with passenger cars, since retractors were voluntarily supplied to 100 percent of the fleet before the baseline date, retractors are also considered voluntary. For MY 1976 and later the attributable costs include what would have been the costs of lap belts plus the incremental cost for lap/shoulder belts over lap belts times the difference in installation rate for MY 1976 to MY 2012 minus the voluntary baseline level of MY 1975. Voluntary costs are based on the MY 1975 installation rate.

Manual Front Outboard Seat Belts Without Retractors. In 1968 all front outboard seats in LTVs were equipped with lap belts. Between 1969 and 1981, when all MY 1981 LTVs were equipped with lap/shoulder belts, there was a declining percentage of LTVs that were equipped with lap belts and an increasing percentage of LTVs equipped with lap/shoulder belts. As far as we know, there were no separate lap and shoulder belts used on LTVs, and all of the LTV systems were integral lap/shoulder belts.

It is assumed that manually adjusted lap belts without retractors were installed through December 31, 1971. Although no cost or weight analysis was performed on manual front outboard seat belts in LTVs for this time period, the seat belts used in LTVs are assumed to be very similar to those in passenger cars for the same time frame. Consequently, the weight and cost numbers from the passenger car study are used to determine the LTV figures,[138] The seat belt and shoulder belt anchorages in LTVs, however, differed from those in the passenger cars. Therefore, the figures from a study of belt assembly anchorages in LTVs are used.[139] Table 208-8 shows the arithmetic average weight and consumer cost per seat for LTVs for the manual front outboard seat belts without retractors, including the seat belt and shoulder belt assembly anchorages. These values are used through 1971, and then the learning curve is applied using the consumer costs in Table 208-9.

TABLE 208-8
AVERAGE WEIGHT AND CONSUMER COST PER SEAT OF MANUAL FRONT OUTBOARD SEAT BELTS WITHOUT RETRACTORS IN LTVS

BELT ASSEMBLIES	WEIGHT IN POUNDS	CONSUMER COST ($2012)
Lap Belt Only (1968)	2.25	$25.52
3-Point Belt (1966-1971)	2.54	$27.20

Manual Front Outboard Seat Belts With Retractors. Beginning January 1, 1972, front outboard seats integral lap/shoulder seat belts, seat belt retractors, and seat belt warning systems were required on passenger cars. It is assumed that the seat belt retractors and seat belt warning systems were added to the LTV outboard seat belt assemblies at this time. We know of no separate lap and shoulder belts ever being used on LTVs. The figures for the 3-point belts were derived from a cost and weight analysis performed on six LTVs,[140] [141] however, there was no analysis performed on the lap belts. Since there was little difference in the cost and weight of the lap belt and 3-point belts without retractors (Table 208-8), the cost of the lap belt with retractor was determined by subtracting the differences from Table 208-8 of 0.29 pounds from the weight and $1.68 from the cost of the 3-point belts with retractors. Table 208-9 shows the average weight and consumer cost per seat for the manual front outboard seat belts with retractors for LTVs. These figures include the seat belt and shoulder belt assembly anchorages. For the LTV front outboard lap belt analysis, the cost from MY 1968 to MY 1971 used the Table 208-8

[138] McLean, Eckel, & Cowan, 1978, Docket No. 2011-0066-0082.
[139] Osen & Ludtke, 1985.
[140] Fladmark & Khadilkar, 1996, Docket No. 2011-0066-0024.
[141] Fladmark & Khadilkar, 1997, Docket No. 2011-0066-0021 and 0020.

without retractors cost and weight of $25.52 and 2.25 pounds per lap belt and then applied the learning curve to the $41.31 with retractors from Table 208-9 for MY 1972 and thereafter.

TABLE 208-9 AVERAGE WEIGHT AND CONSUMER COST PER SEAT OF MANUAL FRONT OUTBOARD SEAT BELTS WITH RETRACTORS IN LTVS		
BELT ASSEMBLIES	**WEIGHT IN POUNDS**	**CONSUMER COST ($2012)**
Lap Belt Only	4.49	$41.31
3-Point Belt (1972-1996)	4.78	$42.99

The front outboard lap/shoulder belt analysis assumed costs of $27.20 for lap/shoulder belts without retractors from Table 208-8 for MY 1968 to MY 1972, then applied the learning curve to the $42.99 estimate from Table 208-9 starting in MY 1972. The $42.99 cost estimate was based on 1989 models. The cost of manual front outboard seat belts for LTVs in 1989 was $3.88 more expensive than the manual front outboard seat belts in passenger cars in 1989. This relationship held for some of the earlier years, but not all years, even though we used teardown studies for passenger cars and the learning curve for LTVs. For example, in 1974, the teardown study for passenger cars estimated the cost at $45.18 per seat compared to the learning curve for LTVs estimate of $48.81. In 1980, the teardown study for passenger cars estimated the cost at $45.06 per seat compared to the learning curve for LTVs estimate of $45.03.

After January 1, 1976, the FMVSS No. 208 requirements for LTVs were similar to those for passenger cars, offering three possible options that were discussed earlier in this paper. Manufacturers avoided the automatic protection options for LTVs. However, certain types of trucks were still exempt from 3-point belts. The proportion of LTVs installed with 3-point belts increased over the years until 1981 when 100 percent of LTVs were equipped with 3-point belts in the front outboard seating positions.

Rear Outboard Seat Belts. On September 30, 1970, (35 FR 15222), a final rule was published in the Federal Register extending FMVSS No. 208 (lap belts at all designated seating positions) to LTVs. The NPRM was published in the Federal Register on September 20, 1969, (34 FR 14660), making the baseline date September 1, 1969, or MY 1970 for lap belts. However, as discussed above for passenger cars, for this analysis we decided that all lap belt costs would be attributed to the safety standards.

From 1966 to 1986 rear-outboard seats were equipped with lap only belts. Integral 3-point belts were voluntarily installed in LTVs starting in 1987, and subsequently in a gradually increasing list of models. On November 2, 1989, (54 FR 46257), NHTSA published a final rule that extended the requirements for rear-outboard seats with lap/shoulder belts to convertibles, LTVs, multipurpose vehicles, and small buses other than school buses that took effect September 1, 1991. As in the earlier final rule, center seating positions and non-forward-facing seating positions were excluded from the requirements. The NPRM was published in the Federal Register on November 29, 1988, (53 FR 47982), making the baseline date September 1, 1988, or MY 1989. Since 100 percent of the fleet did not have 3-point belts in the rear outboard seats of LTVs by the baseline date, 3-point belts in the rear outboard seats of LTVs would have all been considered voluntary through MY 1989 and the voluntary percentage (16.8%) would have been held at that MY 1989 baseline level through MY 2012. However, attributable costs will be the cost of lap belts through MY 1989 and then for MY 1990 to MY 2012, what the cost of lap belts would have been plus the incremental cost for lap/shoulder belts over lap belts times the difference in the installation rate for MY 1990 to MY 2012 minus the voluntary baseline level of MY 1989. By 1992, 100 percent of LTVs were equipped with integral 3-point belts in all forward-facing rear outboard-seating positions.

Although no cost or weight analysis was performed on manual rear outboard seat belts in LTVs for this time period, the seat belts used in LTVs are assumed to be very similar to those in passenger cars for the same time frame. Consequently, the weight and cost numbers from the passenger car study are used to determine the LTV figures.[142] [143] Table 208-10 shows the arithmetic average weight and consumer cost per seat for the manual rear outboard seat belts with and without retractors. For lap belts, the $20.31 figure was used through 1971, then the learning curve was applied to the $23.27 with a MY 1980 baseline for MY 1972 to MY 1991. For lap/shoulder belts, then the learning curve was applied to $22.74 with a MY 1992 baseline for MY 1987 to MY 2012.

TABLE 208-10
AVERAGE WEIGHT AND CONSUMER COST PER SEAT OF REAR OUTBOARD SEAT BELTS IN LTVS

BELT ASSEMBLIES	WEIGHT IN POUNDS	CONSUMER COST ($2012)
Without Retractors		
Lap Only (1968)	1.83	$20.31
With Retractors		
Lap Only (1972-1989)	2.79	$23.27
3-Point Belt (1988 to 1992)	2.58	$22.74

Front and Rear Center Seat Belts. On September 30, 1970, (35 FR 15222), a final rule was published in the Federal Register extending FMVSS No. 208 (lap belts at all designated seating positions) to LTVs. The NPRM was published in the Federal Register on September 20, 1969, (34 FR 14660), making the baseline date September 1, 1969, or MY 1970 for lap belts. However, as discussed above, NHTSA has decided to consider all lap belts as being attributable to the safety standards.

The lap only belts at the front and rear center seat positions for this time period were airline-style belts without a retractor. Again, no cost or weight analysis was performed on front and rear center lap belts in LTVs for this time period; consequently, the weight and cost numbers from the passenger car studies are used to determine the LTV figures.[144] [145] Table 208-11 shows the estimated weight and consumer cost per seat for the front and rear center lap belts without retractors. No cost is included for anchorages, since they are shared with the outboard seats.

[142] McLean, Eckel, & Cowan, 1978, Docket No. 2011-0066-0082.
[143] Fladmark & Khadilkar, 1992, Docket No. 2011-0066-0030.
[144] McLean, Eckel, & Cowan, 1978, Docket No. 2011-0066-0082.
[145] Gladstone, Harvey & Lesczhik,1982, Docket No. 2011-0066-0066.

TABLE 208-11 AVERAGE WEIGHT AND CONSUMER COST PER SEAT OF FRONT AND REAR CENTER LAP BELTS WITHOUT RETRACTORS IN LTVS		
BELT ASSEMBLIES	**WEIGHT IN POUNDS**	**CONSUMER COST ($2012)**
Front Center		
Lap Only (1968-1974)	0.90	$17.80
Lap Only (1979-1981)	0.79	$16.48
Rear Center		
Lap Only (1968-1974)	1.02	$17.41
Lap Only (1979-1981)	0.75	$15.38
Lap Only (1992-1993)	1.09	$14.00

There is a decrease in cost over time in Table 208-11. The $16.48 for MY 1980 for the front center lap belt and $14.00 for MY 1992 for the rear center lap belt are used in the learning curve. The weights used for the front center lap belts were 0.90 pounds from MY 1968 to MY 1974, decreasing by 0.02 pounds per year from MY 1975 to MY 1978, and then 0.79 pounds for MY 1979 and thereafter. The weights used for the rear center lap belts were 1.02 pounds from MY 1968 to MY 1974, decreasing by 0.054 pounds per year from MY 1975 to MY 1978, 0.75 pounds for MY 1979 to MY 1981, increasing by 0.03 pounds per year from MY 1982 to MY 1991, then 1.09 pounds for MY 1992 and thereafter.

On December 8, 2004, (69 FR 70904), in response Anton’s Law, signed on December 4, 2002, NHTSA published a final rule mandating lap/shoulder belts for all forward-facing rear seating positions, including center seats, and all rear facing seating positions (the back of the station wagon style), in all motor vehicles with GVWR of less than 10,000 pounds (all passenger cars and LTVs). The NPRM was published in the Federal Register on August 6, 2003, (68 FR 46546), making the baseline date September 1, 2002, or MY 2003.

The phase-in effective dates are:

- 50 percent of all vehicles manufactured from September 1, 2005, to August 31, 2006;
- 80 percent of all vehicles manufactured from September 1, 2006, to August 31, 2007;
- 100 percent of all vehicles manufactured on or after September 1, 2007, must comply.

In 1998, manufacturers began voluntarily installing lap/shoulder belts in the rear center seating position of LTVs. By MY 2003, the baseline year, 51.75 percent of LTVs were equipped with rear center lap/shoulder belts. Since 100 percent of the fleet did not have 3-point belts in the rear center seats of LTVs by the baseline date, 3-point belts in the rear center seats of LTVs would have all been considered voluntary through MY 2003 and the voluntary percentage (51.75%) would have been held at that MY 2003 baseline level through MY 2012. However, attributable costs will be the cost of lap belts through MY 2003 and then for MY 2004 to MY 2012, what the cost of lap belts would have been plus the difference in costs for lap/shoulder belts between the installation rates for MY 2004 to MY 2012 minus the voluntary baseline level of MY 2003.

The consumer cost estimate of rear center 3-point seat belts of 3.03 pounds and $36.55 in 2012 dollars was calculated in the Final Economic Assessment[146] on adding lap/shoulder belts to the center seats of passenger cars and LTVs and was based partly on the teardown of three existing systems.[147] The $36.55 cost estimate was based on MY 1996 vehicles and learning was applied from MY 1998 to MY 2012.

Summary Calculations for Seat Belts. The total weight and consumer cost of seat belt assemblies and anchorages for MYs 1968-2012 were calculated. The starting point for the calculations is the number of seating positions in the average passenger car and LTV by type of position (front outboard, front center, rear outboard, rear center). The rear outboard seats and rear center seats include the second row, the third row and in some full-size vans the fourth row. All of these rear seating positions are averaged and combined into the rear outboard or rear center position. For example in MY 2MY 2005, every passenger car had 2 front outboard seats, 11.49 percent of cars had a front center seat (0.1149 seats in the calculations), the average car had 1.96 rear outboard seats (i.e., 98 percent of cars have 2 rear outboard seats and 2 percent of cars did not have a back seat) and 91.8 percent of passenger cars had a rear center seat (0.918 in the calculations). No MY 2005 passenger car had a third row of forward-facing seats. However, a small proportion of cars still had rear-facing third row seats (Taurus, Sable, and Mercedes E wagons) amounting to only 0.0019 seats per car, which were added into the rear center seat position making it total 0.919. The numbers are different for MY 2010. Every MY 2010 passenger car had two front outboard seats, but the front center seat was available in only 1.12 percent of cars (0.0112 seats in the calculations), the average car had 1.99 rear outboard seats (i.e., 99.28 percent of cars had two rear outboard seats and 0.72 percent of cars did not have a back seat) and 92.7 percent of passenger cars had a rear center seat (0.927 in the calculations). No MY 2010 passenger car had a third row of forward-facing seats and no models still had the rear-facing third row seats.

The arithmetic is slightly more complicated for LTVs. For example in MY 2005, every LTV had 2 front outboard seats, 32.70 percent of LTVs had a front center seat (0.3270 in the calculations), the average LTV had 2.32 rear outboard seats (including the second, third, and fourth rows), and the average MY 2005 LTV had 0.9372 rear center seats (including the second, third, and fourth rows). For MY 2010, every LTV had 2 front outboard seats, 24.88 percent of LTVs had a front center seat, the average LTV had 2.34 rear outboard seats (including the second, third, and fourth rows), and the average MY 2010 LTV had 0.9718 rear center seats (including the second, third, and fourth rows).

Data was collected on the number of seating positions per average LTV and passenger car from the following sources. The model years were divided into six groups, i.e., 1966-1976, 1977-1984, 1985-1994, 1995-2002, 2003-2007, and 2008-2012.

[146] NHTSA. (2004, June). *Final Economic Assessment and Final Regulatory Flexibility Analysis, Costs of Putting a Shoulder Belt in the Center Seats of Passenger Cars and LTVs*. Washington, DC: Author. In Docket No. 2004-18726-0002.
[147] Ibid.

1. 1966-1976 – National Crash Severity Study, which was a 1976-1978 predecessor of the National Automotive Sampling System file. NCSS had a variable indicating how many seats were in the vehicle.

2. 1977-1984 – NASS file. In 1982-1986, NASS had a variable indicating how many seats were in a car.

3. 1985-1994 – 1990 Polk registration file and Branham Automobile Reference Book.[148] The Polk file provides the sales figures of all 1990 passenger vehicles broken out by make and model, while the Branham book identifies the number of seating positions in each of the 1990 make-models. The sales figures for each seating position are divided by the overall sales figures to determine the percentage market share per position.

4. 1995-2002 – 1999 Polk registration file and Branham Automobile Reference Book. We assume that the distribution of belts by seating position for 1999 is a proxy measure for 1995 to 2002.

5. 2003-2007- Model year 2005 data collected from cars.com and meshed with Polk registrations for 2005. We assume that the distribution of belts by seating position for 2005 is a proxy measure for 2003 to 2007.

6. 2008-2012 - Model year 2010 data collected from cars.com and meshed with Polk registrations for 2010. We assume that the distribution of belts by seating position for 2010 is a proxy measure for 2008 to 2012.

The second step in the calculations is to determine the type of seat belt (lap belt, lap/shoulder belt, or automatic belt) used in each seating position for each model year for the average passenger car and LTV. These data were taken from the Kahane report, *Lives Saved by Vehicle Safety Technologies and Associated Federal Motor Vehicle Safety Standards, 1960 to 2012* (Report No. DOT HS 812 069).

Since weights and costs are different between lap and lap/shoulder belts, and front seats and rear seats, and outboard versus center seats, the seat belts were divided into the following groups for analysis.

- Lap belts, front seat outboard (see Table 208-12a, 12b, 12c, and 12d)
- Lap belts, front seat center (see Table 208-13a, 13b, 13c and 13d)
- Lap belts, rear seat outboard (see Table 208-14a, 14b, 14c, and 14d)
- Lap belts, rear seat center (see Table 208-15a, 15b, 15c, and 15d)
- Lap/shoulder belts, front seat outboard (see Table 208-16a, 16b, 16c, and 16d)
- Lap/shoulder belts, rear seat outboard (see Table 208-17, 17b, 17c, and 17d)
- Lap/shoulder belts, rear seat center (see Table 208-18a, 18b, 18c, and 18d)
- Automatic belts, front seat outboard (see Table 208-19a and Table 208-19b)

[148] Branham, B. P. (1985 to 2001). *Branham automobile reference kook.* Santa, Monica, CA: Branham Publishing Company.

The third step is to apply the learning curve to each group analyzed.

The fourth step is to multiply the number of average seating positions per vehicle, times the percentage of the new vehicle fleet that had lap or lap/shoulder belts, times the learning curve cost in that model year to determine the cost per model year. These were each done separately for passenger cars and LTVs because some of the costs per seat belt type are different.

The fifth step is to consider the baseline and determine voluntary and attributable weights and costs. In the tables below the a Tables (like 208-12a) show the number of seats and the percentage of the fleet where the belt was installed. The b tables (like 208-12b) show the weight and consumer cost. The c tables (like 208-12c) show the distribution between voluntary and attributable weights and costs for passenger cars. The d tables (like 208-12d) show the distribution between voluntary and attributable weights and costs for LTVs. Average costs are costs (in most cases after applying the learning curve) multiplied by the number of seats and multiplied by the percentage of the vehicles equipped. The average weight per vehicle also has three factors: weight of the technology * number of seats * percent equipped.

Table 208-12a
Average Number of Seating Positions and Percentage of Fleet Equipped
Manual Lap Belts in Front Outboard Seats

	PC	LTV	PC	LTV
Model Year	**Number Of Seats**	**Number Of Seats**	**Percent Equipped**	**Percent Equipped**
1968	2	2	12.5	100
1969	2	2	0	97.19
1970	2	2	0	96.79
1971	2	2	0	96.17
1972	2	2	0	94.49
1973	2	2	0	94.6
1974	2	2	0	59.52
1975	2	2	0	56.48
1976	2	2	0	55.28
1977	2	2	0	15.67
1978	2	2	0	14.93
1979	2	2	0	15.95
1980	2	2	0	5.72
1981	2	2	0	0

Table 208-12b						
Weight (lb) and Consumer Cost (2012$)						
Manual Lap Belts in Front Outboard Seats						
	PC	PC	PC	LTV	LTV	LTV
Model Year	Cost per Belt	Ave. Cost Per Veh.	Ave. Weight	Cost per Belt	Ave. Cost Per Veh.	Ave. Weight
1968	$25.91	$6.48	0.60	$25.52	$51.04	4.50
1969	$25.91	$0.00	0	$25.52	$49.61	4.37
1970	$25.91	$0.00	0	$25.52	$49.40	4.36
1971	$38.34	$0.00	0	$25.52	$49.09	4.33
1972	$38.34	$0.00	0	$41.41	$78.25	8.49
1973	$38.34	$0.00	0	$41.31	$78.15	8.50
1974	$0.00	$0.00	0	$41.25	$49.11	5.34
1975	$0.00	$0.00	0	$41.21	$46.55	5.07
1976	$0.00	$0.00	0	$41.15	$45.49	4.96
1977	$0.00	$0.00	0	$41.13	$12.89	1.41
1978	$0.00	$0.00	0	$41.11	$12.27	1.34
1979	$0.00	$0.00	0	$41.09	$13.11	1.43
1980	$0.00	$0.00	0	$41.09	$4.70	0.51
1981	$0.00	$0.00	0	$41.09	$0.00	0

Table 208-12c						
Manual Lap Belts Front Outboard Seats - Passenger Cars						
Model Year	Weight (lb)			Consumer Cost (2012$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0	0.60	0.60	$0.00	$6.48	$6.48
1969	0	0	0	$0.00	$0.00	$0.00

Table 208-12d						
Manual Lap Belts Front Outboard Seats - LTVs						
Model	**Weight (lb)**			**Consumer Cost (2012$)**		
Year	**Voluntary**	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	0	4.50	4.50	$0.00	$51.04	$51.04
1969	0	4.37	4.37	$0.00	$49.61	$49.61
1970	0	4.36	4.36	$0.00	$49.40	$49.40
1971	0	4.33	4.33	$0.00	$49.09	$49.09
1972	0	8.49	8.49	$0.00	$78.25	$78.25
1973	0	8.50	8.50	$0.00	$78.15	$78.15
1974	0	5.34	5.34	$0.00	$49.11	$49.11
1975	0	5.07	5.07	$0.00	$46.55	$46.55
1976	0	4.96	4.96	$0.00	$45.49	$45.49
1977	0	1.41	1.41	$0.00	$12.89	$12.89
1978	0	1.34	1.34	$0.00	$12.27	$12.27
1979	0	1.43	1.43	$0.00	$13.11	$13.11
1980	0	0.51	0.51	$0.00	$4.70	$4.70
1981	0	0	0	$0.00	$0.00	$0.00

Table 208-13a				
Average Number of Seating Positions and				
Percentage of Fleet Equipped				
Manual Lap Belts in Front Center Seat				
	PC	**LTV**	**PC**	**LTV**
Model Year	**Number Of Seats**	**Number Of Seats**	**Percent Equipped**	**Percent Equipped**
1968	0.47	0.56	100	100
1969	0.47	0.56	100	100
1970	0.47	0.56	100	100
1971	0.47	0.56	100	100
1972	0.47	0.56	100	100
1973	0.47	0.56	100	100
1974	0.47	0.56	100	100
1975	0.47	0.56	100	100
1976	0.47	0.56	100	100
1977	0.33	0.61	100	100
1978	0.33	0.61	100	100
1979	0.33	0.61	100	100

1980	0.33	0.61	100	100
1981	0.33	0.61	100	100
1982	0.33	0.61	100	100
1983	0.33	0.61	100	100
1984	0.33	0.61	100	100
1985	0.33	0.61	100	100
1986	0.33	0.61	100	100
1987	0.23	0.69	100	100
1988	0.23	0.69	100	100
1989	0.23	0.69	100	100
1990	0.23	0.69	100	100
1991	0.23	0.69	100	100
1992	0.23	0.69	100	100
1993	0.23	0.69	100	100
1994	0.23	0.69	100	100
1995	0.21	0.68	100	100
1996	0.21	0.68	100	100
1997	0.21	0.68	100	100
1998	0.21	0.68	100	100
1999	0.21	0.68	100	100
2000	0.21	0.68	100	100
2001	0.21	0.68	100	100
2002	0.21	0.68	100	100
2003	0.11	0.33	100	100
2004	0.11	0.33	100	100
2005	0.11	0.33	100	100
2006	0.11	0.33	100	100
2007	0.11	0.33	100	100
2008	0.01	0.25	100	100
2009	0.01	0.25	100	100
2010	0.01	0.25	100	100
2011	0.01	0.25	100	100
2012	0.01	0.25	100	100

Table 208-13b						
Weight (lb) and Consumer Cost (2012$)						
Manual Lap Belts in Front Center Seat						
	PC	PC	PC	LTV	LTV	LTV
Model Year	**Cost per Belt**	**Ave. Cost Per Veh.**	**Ave. Weight**	**Cost per Belt**	**Ave. Cost Per Veh.**	**Ave. Weight**
1968	$18.09	$8.50	0.42	$18.09	$10.13	0.50
1969	$17.81	$8.37	0.42	$17.81	$9.98	0.50
1970	$17.62	$8.28	0.42	$17.62	$9.87	0.50
1971	$17.44	$8.20	0.42	$17.44	$9.77	0.50
1972	$17.28	$8.12	0.42	$17.28	$9.67	0.50
1973	$17.12	$8.05	0.42	$17.12	$9.59	0.50
1974	$17.01	$8.00	0.42	$17.01	$9.53	0.50
1975	$16.92	$7.95	0.41	$16.92	$9.47	0.50
1976	$16.82	$7.90	0.40	$16.82	$9.42	0.50
1977	$16.71	$5.52	0.28	$16.71	$10.20	0.55
1978	$16.62	$5.48	0.27	$16.62	$10.14	0.55
1979	$16.54	$5.46	0.26	$16.54	$10.09	0.55
1980	$16.48	$5.44	0.26	$16.48	$10.05	0.55
1981	$16.43	$5.42	0.26	$16.43	$10.02	0.55
1982	$16.38	$5.40	0.26	$16.38	$9.99	0.55
1983	$16.32	$5.39	0.26	$16.32	$9.96	0.55
1984	$16.26	$5.37	0.26	$16.26	$9.92	0.55
1985	$16.20	$5.35	0.26	$16.20	$9.88	0.55
1986	$16.14	$5.33	0.26	$16.14	$9.85	0.55
1987	$16.09	$3.70	0.18	$16.09	$11.10	0.62
1988	$16.04	$3.69	0.18	$16.04	$11.07	0.62
1989	$16.00	$3.68	0.18	$16.00	$11.04	0.62
1990	$15.96	$3.67	0.18	$15.96	$11.01	0.62
1991	$15.92	$3.66	0.18	$15.92	$10.99	0.62
1992	$15.89	$3.65	0.18	$15.89	$10.96	0.62
1993	$15.85	$3.65	0.18	$15.85	$10.94	0.62
1994	$15.81	$3.64	0.18	$15.81	$10.91	0.62
1995	$15.78	$3.31	0.17	$15.78	$10.73	0.61
1996	$15.74	$3.31	0.17	$15.74	$10.71	0.61
1997	$15.71	$3.30	0.17	$15.71	$10.68	0.61
1998	$15.68	$3.29	0.17	$15.68	$10.66	0.61
1999	$15.64	$3.28	0.17	$15.64	$10.64	0.61
2000	$15.61	$3.28	0.17	$15.61	$10.61	0.61

2001	$15.58	$3.27	0.17	$15.58	$10.59	0.61
2002	$15.54	$3.26	0.17	$15.54	$10.57	0.61
2003	$15.52	$1.78	0.09	$15.52	$5.07	0.29
2004	$15.49	$1.78	0.09	$15.49	$5.06	0.29
2005	$15.46	$1.78	0.09	$15.46	$5.05	0.29
2006	$15.43	$1.77	0.09	$15.43	$5.05	0.29
2007	$15.41	$1.77	0.09	$15.41	$5.04	0.29
2008	$15.39	$0.17	0.01	$15.39	$3.83	0.22
2009	$15.37	$0.17	0.01	$15.37	$3.82	0.22
2010	$15.36	$0.17	0.01	$15.36	$3.82	0.22
2011	$15.34	$0.17	0.01	$15.34	$3.82	0.22
2012	$15.32	$0.17	0.01	$15.32	$3.81	0.22

Table 208-13c

Manual Lap Belts Front Center Seat - Passenger Cars

Model Year	Weight (lb)			Consumer Cost (2012$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0	0.42	0.42	0	$8.50	$8.50
1969	0	0.42	0.42	0	$8.37	$8.37
1970	0	0.42	0.42	0	$8.28	$8.28
1971	0	0.42	0.42	0	$8.20	$8.20
1972	0	0.42	0.42	0	$8.12	$8.12
1973	0	0.42	0.42	0	$8.05	$8.05
1974	0	0.42	0.42	0	$8.00	$8.00
1975	0	0.41	0.41	0	$7.95	$7.95
1976	0	0.40	0.40	0	$7.90	$7.90
1977	0	0.28	0.28	0	$5.52	$5.52
1978	0	0.27	0.27	0	$5.48	$5.48
1979	0	0.26	0.26	0	$5.46	$5.46
1980	0	0.26	0.26	0	$5.44	$5.44
1981	0	0.26	0.26	0	$5.42	$5.42
1982	0	0.26	0.26	0	$5.40	$5.40
1983	0	0.26	0.26	0	$5.39	$5.39
1984	0	0.26	0.26	0	$5.37	$5.37
1985	0	0.26	0.26	0	$5.35	$5.35
1986	0	0.26	0.26	0	$5.33	$5.33
1987	0	0.18	0.18	0	$3.70	$3.70
1988	0	0.18	0.18	0	$3.69	$3.69

1989	0	0.18	0.18	0	$3.68	$3.68
1990	0	0.18	0.18	0	$3.67	$3.67
1991	0	0.18	0.18	0	$3.66	$3.66
1992	0	0.18	0.18	0	$3.65	$3.65
1993	0	0.18	0.18	0	$3.65	$3.65
1994	0	0.18	0.18	0	$3.64	$3.64
1995	0	0.17	0.17	0	$3.31	$3.31
1996	0	0.17	0.17	0	$3.31	$3.31
1997	0	0.17	0.17	0	$3.30	$3.30
1998	0	0.17	0.17	0	$3.29	$3.29
1999	0	0.17	0.17	0	$3.28	$3.28
2000	0	0.17	0.17	0	$3.28	$3.28
2001	0	0.17	0.17	0	$3.27	$3.27
2002	0	0.17	0.17	0	$3.26	$3.26
2003	0	0.09	0.09	0	$1.78	$1.78
2004	0	0.09	0.09	0	$1.78	$1.78
2005	0	0.09	0.09	0	$1.78	$1.78
2006	0	0.09	0.09	0	$1.77	$1.77
2007	0	0.09	0.09	0	$1.77	$1.77
2008	0	0.01	0.01	0	$0.17	$0.17
2009	0	0.01	0.01	0	$0.17	$0.17
2010	0	0.01	0.01	0	$0.17	$0.17
2011	0	0.01	0.01	0	$0.17	$0.17
2012	0	0.01	0.01	0	$0.17	$0.17

Table 208-13d

Manual Lap Belts Front Center Seat - LTVs

Model Year	Weight (lb)			Consumer Cost (2012$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0	0.50	0.50	0	$10.13	$10.13
1969	0	0.50	0.50	0	$9.98	$9.98
1970	0	0.50	0.50	0	$9.87	$9.87
1971	0	0.50	0.50	0	$9.77	$9.77
1972	0	0.50	0.50	0	$9.67	$9.67
1973	0	0.50	0.50	0	$9.59	$9.59
1974	0	0.50	0.50	0	$9.53	$9.53
1975	0	0.50	0.50	0	$9.47	$9.47
1976	0	0.50	0.50	0	$9.42	$9.42
1977	0	0.55	0.55	0	$10.20	$10.20

1978	0	0.55	0.55	0	$10.14	$10.14
1979	0	0.55	0.55	0	$10.09	$10.09
1980	0	0.55	0.55	0	$10.05	$10.05
1981	0	0.55	0.55	0	$10.02	$10.02
1982	0	0.55	0.55	0	$9.99	$9.99
1983	0	0.55	0.55	0	$9.96	$9.96
1984	0	0.55	0.55	0	$9.92	$9.92
1985	0	0.55	0.55	0	$9.88	$9.88
1986	0	0.55	0.55	0	$9.85	$9.85
1987	0	0.62	0.62	0	$11.10	$11.10
1988	0	0.62	0.62	0	$11.07	$11.07
1989	0	0.62	0.62	0	$11.04	$11.04
1990	0	0.62	0.62	0	$11.01	$11.01
1991	0	0.62	0.62	0	$10.99	$10.99
1992	0	0.62	0.62	0	$10.96	$10.96
1993	0	0.62	0.62	0	$10.94	$10.94
1994	0	0.62	0.62	0	$10.91	$10.91
1995	0	0.61	0.61	0	$10.73	$10.73
1996	0	0.61	0.61	0	$10.71	$10.71
1997	0	0.61	0.61	0	$10.68	$10.68
1998	0	0.61	0.61	0	$10.66	$10.66
1999	0	0.61	0.61	0	$10.64	$10.64
2000	0	0.61	0.61	0	$10.61	$10.61
2001	0	0.61	0.61	0	$10.59	$10.59
2002	0	0.61	0.61	0	$10.57	$10.57
2003	0	0.29	0.29	0	$5.07	$5.07
2004	0	0.29	0.29	0	$5.06	$5.06
2005	0	0.29	0.29	0	$5.05	$5.05
2006	0	0.29	0.29	0	$5.05	$5.05
2007	0	0.29	0.29	0	$5.04	$5.04
2008	0	0.22	0.22	0	$3.83	$3.83
2009	0	0.22	0.22	0	$3.82	$3.82
2010	0	0.22	0.22	0	$3.82	$3.82
2011	0	0.22	0.22	0	$3.82	$3.82
2012	0	0.22	0.22	0	$3.81	$3.81

Table 208-14a				
Average Number of Seating Positions and				
Percentage of Fleet Equipped				
Manual Lap Belts in Rear Outboard Seats				
	PC	LTV	PC	LTV
Model Year	Number Of Seats	Number Of Seats	Percent Equipped	Percent Equipped
1968	1.98	0.39	100	100
1969	1.98	0.39	100	100
1970	1.98	0.39	100	100
1971	1.98	0.39	99.55	100
1972	1.98	0.39	99.62	100
1973	1.98	0.39	99.65	100
1974	1.98	0.39	99.39	100
1975	1.98	0.39	99.04	100
1976	1.98	0.39	99.29	100
1977	1.96	0.83	99.46	100
1978	1.96	0.83	99.39	100
1979	1.96	0.83	99.36	100
1980	1.96	0.83	99.26	100
1981	1.96	0.83	98.29	100
1982	1.96	0.83	95.92	100
1983	1.96	0.83	94.18	100
1984	1.96	0.83	94.45	100
1985	1.96	0.83	94.25	100
1986	1.96	0.83	93.14	100
1987	1.96	1.31	90.38	99.71
1988	1.96	1.31	69.33	97.16
1989	1.96	1.31	32.33	83.2
1990	1.96	1.31	0	79.99
1991	1.96	1.31	0	67.75
1992	1.96	1.31	0	0

Table 208-14b						
Weight (lb) and Consumer Cost (2012$)						
Manual Lap Belts in Rear Outboard Seats						
	PC	**PC**	**PC**	**LTV**	**LTV**	**LTV**
Model Year	**Cost per Belt**	**Ave. Cost Per Veh.**	**Ave. Weight**	**Cost per Belt**	**Ave. Cost Per Veh.**	**Ave. Weight**
1968	$20.31	$40.21	3.62	$20.31	$7.92	0.71
1969	$20.31	$40.21	3.62	$20.31	$7.92	0.71
1970	$20.31	$40.21	3.62	$20.31	$7.92	0.71
1971	$20.31	$40.03	3.61	$20.31	$7.92	0.71
1972	$24.36	$48.05	5.50	$24.36	$9.50	1.09
1973	$24.15	$47.65	5.50	$24.15	$9.42	1.09
1974	$24.00	$47.23	5.49	$24.00	$9.36	1.09
1975	$23.87	$46.81	5.47	$23.87	$9.31	1.09
1976	$23.73	$46.66	5.48	$23.73	$9.26	1.09
1977	$23.59	$45.99	5.44	$23.59	$19.58	2.32
1978	$23.46	$45.71	5.44	$23.46	$19.47	2.32
1979	$23.35	$45.48	5.43	$23.35	$19.38	2.32
1980	$23.27	$45.27	5.43	$23.27	$19.31	2.32
1981	$23.20	$44.69	5.37	$23.20	$19.25	2.32
1982	$23.13	$43.49	5.25	$23.13	$19.20	2.32
1983	$23.06	$42.56	5.15	$23.06	$19.14	2.32
1984	$22.98	$42.54	5.16	$22.98	$19.07	2.32
1985	$22.90	$42.29	5.15	$22.90	$19.00	2.32
1986	$22.82	$41.65	5.09	$22.82	$18.94	2.32
1987	$22.75	$40.29	4.94	$22.75	$29.71	3.64
1988	$22.69	$30.83	3.79	$22.69	$28.88	3.55
1989	$22.66	$14.36	1.77	$22.66	$24.70	3.04
1990	$22.64	$0.00	0	$22.64	$23.73	2.92
1991	$22.63	$0.00	0	$22.63	$20.08	2.48
1992	$22.63	$0.00	0	$22.63	$0.00	0

Table 208-14c						
Manual Lap Belts Rear Outboard Seats - Passenger Cars						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	0	3.62	3.62	0	$40.21	$40.21
1969	0	3.62	3.62	0	$40.21	$40.21
1970	0	3.62	3.62	0	$40.21	$40.21
1971	0	3.61	3.61	0	$40.03	$40.03
1972	0	5.50	5.50	0	$48.05	$48.05
1973	0	5.50	5.50	0	$47.65	$47.65
1974	0	5.49	5.49	0	$47.23	$47.23
1975	0	5.47	5.47	0	$46.81	$46.81
1976	0	5.48	5.48	0	$46.66	$46.66
1977	0	5.44	5.44	0	$45.99	$45.99
1978	0	5.44	5.44	0	$45.71	$45.71
1979	0	5.43	5.43	0	$45.48	$45.48
1980	0	5.43	5.43	0	$45.27	$45.27
1981	0	5.37	5.37	0	$44.69	$44.69
1982	0	5.25	5.25	0	$43.49	$43.49
1983	0	5.15	5.15	0	$42.56	$42.56
1984	0	5.16	5.16	0	$42.54	$42.54
1985	0	5.15	5.15	0	$42.29	$42.29
1986	0	5.09	5.09	0	$41.65	$41.65
1987	0	4.94	4.94	0	$40.29	$40.29
1988	0	3.79	3.79	0	$30.83	$30.83
1989	0	1.77	1.77	0	$14.36	$14.36
1990	0	0.00	0.00	0	$0.00	$0.00

Table 208-14d						
Manual Lap Belts Rear Outboard Seats - LTVs						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	0	0.71	0.71	0	$7.92	$7.92
1969	0	0.71	0.71	0	$7.92	$7.92
1970	0	0.71	0.71	0	$7.92	$7.92
1971	0	0.71	0.71	0	$7.92	$7.92
1972	0	1.09	1.09	0	$9.50	$9.50
1973	0	1.09	1.09	0	$9.42	$9.42
1974	0	1.09	1.09	0	$9.36	$9.36
1975	0	1.09	1.09	0	$9.31	$9.31
1976	0	1.09	1.09	0	$9.26	$9.26
1977	0	2.32	2.32	0	$19.58	$19.58
1978	0	2.32	2.32	0	$19.47	$19.47
1979	0	2.32	2.32	0	$19.38	$19.38
1980	0	2.32	2.32	0	$19.31	$19.31
1981	0	2.32	2.32	0	$19.25	$19.25
1982	0	2.32	2.32	0	$19.20	$19.20
1983	0	2.32	2.32	0	$19.14	$19.14
1984	0	2.32	2.32	0	$19.07	$19.07
1985	0	2.32	2.32	0	$19.00	$19.00
1986	0	2.32	2.32	0	$18.94	$18.94
1987	0	3.64	3.64	0	$29.71	$29.71
1988	0	3.55	3.55	0	$28.88	$28.88
1989	0	3.04	3.04	0	$24.70	$24.70
1990	0	2.92	2.92	0	$23.73	$23.73
1991	0	2.48	2.48	0	$20.08	$20.08
1992	0	0.00	0.00	0	$0.00	$0.00

Table 208-15a				
Average Number of Seating Positions and				
Percentage of Fleet Equipped				
Manual Lap Belts in Rear Center Seats				
	PC	LTV	PC	LTV
Model Year	Number Of Seats	Number Of Seats	Percent Equipped	Percent Equipped
1968	0.62	0.09	100	100
1969	0.62	0.09	100	100
1970	0.62	0.09	100	100
1971	0.62	0.09	100	100
1972	0.62	0.09	100	100
1973	0.62	0.09	100	100
1974	0.62	0.09	100	100
1975	0.62	0.09	100	100
1976	0.62	0.09	100	100
1977	0.62	0.14	100	100
1978	0.62	0.14	100	100
1979	0.62	0.14	100	100
1980	0.62	0.14	100	100
1981	0.62	0.14	100	100
1982	0.62	0.14	100	100
1983	0.62	0.14	100	100
1984	0.62	0.14	100	100
1985	0.62	0.14	100	100
1986	0.62	0.14	100	100
1987	0.86	0.26	100	100
1988	0.86	0.26	100	100
1989	0.86	0.26	100	100
1990	0.86	0.26	100	100
1991	0.86	0.26	100	100
1992	0.86	0.26	100	100
1993	0.86	0.26	100	100
1994	0.86	0.26	99.51	100
1995	0.90	0.70	99.44	100
1996	0.90	0.70	98.32	100
1997	0.90	0.70	88.40	100
1998	0.90	0.70	73.37	99.77
1999	0.90	0.70	69.14	98.83

2000	0.90	0.70	57.00	97.78
2001	0.90	0.70	40.41	91.53
2002	0.90	0.70	35.14	75.48
2003	0.92	0.94	17.87	48.25
2004	0.92	0.94	10.40	32.80
2005	0.92	0.94	4.85	22.86
2006	0.92	0.94	0.40	12.70
2007	0.92	0.94	0.29	5.94
2008	0.93	0.97	0	0
2009	0.93	0.97	0	0
2010	0.93	0.97	0	0
2011	0.93	0.97	0	0
2012	0.93	0.97	0	0

Table 208-15b
Weight (lb) and Consumer Cost (2012$)
Manual Lap Belts in Rear Center Seats

	PC	PC	PC	LTV	LTV	LTV
Model Year	**Cost per Belt**	**Ave. Cost Per Veh.**	**Ave. Weight**	**Cost per Belt**	**Ave. Cost Per Veh.**	**Ave. Weight**
1968	$16.04	$9.95	0.63	$16.04	$1.44	0.09
1969	$15.77	$9.78	0.63	$15.77	$1.42	0.09
1970	$15.59	$9.66	0.63	$15.59	$1.40	0.09
1971	$15.41	$9.56	0.63	$15.41	$1.39	0.09
1972	$15.26	$9.46	0.63	$15.26	$1.37	0.09
1973	$15.12	$9.37	0.63	$15.12	$1.36	0.09
1974	$15.02	$9.31	0.63	$15.02	$1.35	0.09
1975	$14.93	$9.26	0.60	$14.93	$1.34	0.09
1976	$14.84	$9.20	0.57	$14.84	$1.34	0.08
1977	$14.74	$9.14	0.53	$14.74	$2.06	0.12
1978	$14.66	$9.09	0.50	$14.66	$2.05	0.11
1979	$14.59	$9.04	0.47	$14.59	$2.04	0.11
1980	$14.53	$9.01	0.47	$14.53	$2.03	0.11
1981	$14.48	$8.98	0.47	$14.48	$2.03	0.11
1982	$14.44	$8.95	0.48	$14.44	$2.02	0.11
1983	$14.39	$8.92	0.50	$14.39	$2.01	0.11
1984	$14.34	$8.89	0.52	$14.34	$2.01	0.12
1985	$14.28	$8.86	0.54	$14.28	$2.00	0.12
1986	$14.23	$8.82	0.56	$14.23	$1.99	0.13
1987	$14.18	$12.20	0.80	$14.18	$3.69	0.24

1988	$14.14	$12.16	0.83	$14.14	$3.68	0.25
1989	$14.10	$12.12	0.85	$14.10	$3.67	0.26
1990	$14.06	$12.09	0.88	$14.06	$3.66	0.27
1991	$14.03	$12.07	0.90	$14.03	$3.65	0.27
1992	$14.00	$12.04	0.94	$14.00	$3.64	0.28
1993	$13.97	$12.01	0.94	$13.97	$3.63	0.28
1994	$13.93	$11.87	0.93	$13.93	$3.62	0.28
1995	$13.90	$12.44	0.98	$13.90	$9.69	0.76
1996	$13.87	$12.28	0.96	$13.87	$9.67	0.76
1997	$13.84	$11.02	0.87	$13.84	$9.65	0.76
1998	$13.82	$9.13	0.72	$13.82	$9.61	0.76
1999	$13.79	$8.58	0.68	$13.79	$9.50	0.75
2000	$13.77	$7.06	0.56	$13.77	$9.38	0.74
2001	$13.75	$5.00	0.40	$13.75	$8.77	0.70
2002	$13.73	$4.34	0.34	$13.73	$7.23	0.57
2003	$13.72	$2.26	0.18	$13.72	$6.21	0.49
2004	$13.72	$1.31	0.10	$13.72	$4.22	0.34
2005	$13.71	$0.61	0.05	$13.71	$2.94	0.23
2006	$13.71	$0.05	0.00	$13.71	$1.63	0.13
2007	$13.71	$0.04	0.00	$13.71	$0.76	0.06
2008	$13.71	$0.00	0.00	$13.71	$0.00	0.00
2009	$13.71	$0.00	0.00	$13.71	$0.00	0.00
2010	$13.71	$0.00	0.00	$13.71	$0.00	0.00
2011	$13.71	$0.00	0.00	$13.71	$0.00	0.00
2012	$13.71	$0.00	0.00	$13.71	$0.00	0.00

Table 208-15c						
Manual Lap Belts Rear Center Seats - Passenger Cars						
Model Year	Weight (lb)			Consumer Cost (2012$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0	0.63	0.63	$0.00	$9.95	$9.95
1969	0	0.63	0.63	$0.00	$9.78	$9.78
1970	0	0.63	0.63	$0.00	$9.66	$9.66
1971	0	0.63	0.63	$0.00	$9.56	$9.56
1972	0	0.63	0.63	$0.00	$9.46	$9.46
1973	0	0.63	0.63	$0.00	$9.37	$9.37
1974	0	0.63	0.63	$0.00	$9.31	$9.31
1975	0	0.60	0.60	$0.00	$9.26	$9.26
1976	0	0.57	0.57	$0.00	$9.20	$9.20
1977	0	0.53	0.53	$0.00	$9.14	$9.14
1978	0	0.50	0.50	$0.00	$9.09	$9.09
1979	0	0.47	0.47	$0.00	$9.04	$9.04
1980	0	0.47	0.47	$0.00	$9.01	$9.01
1981	0	0.47	0.47	$0.00	$8.98	$8.98
1982	0	0.48	0.48	$0.00	$8.95	$8.95
1983	0	0.50	0.50	$0.00	$8.92	$8.92
1984	0	0.52	0.52	$0.00	$8.89	$8.89
1985	0	0.54	0.54	$0.00	$8.86	$8.86
1986	0	0.56	0.56	$0.00	$8.82	$8.82
1987	0	0.80	0.80	$0.00	$12.20	$12.20
1988	0	0.83	0.83	$0.00	$12.16	$12.16
1989	0	0.85	0.85	$0.00	$12.12	$12.12
1990	0	0.88	0.88	$0.00	$12.09	$12.09
1991	0	0.90	0.90	$0.00	$12.07	$12.07
1992	0	0.94	0.94	$0.00	$12.04	$12.04
1993	0	0.94	0.94	$0.00	$12.01	$12.01
1994	0	0.93	0.93	$0.00	$11.87	$11.87
1995	0	0.98	0.98	$0.00	$12.44	$12.44
1996	0	0.96	0.96	$0.00	$12.28	$12.28
1997	0	0.87	0.87	$0.00	$11.02	$11.02
1998	0	0.72	0.72	$0.00	$9.13	$9.13
1999	0	0.68	0.68	$0.00	$8.58	$8.58
2000	0	0.56	0.56	$0.00	$7.06	$7.06
2001	0	0.40	0.40	$0.00	$5.00	$5.00
2002	0	0.34	0.34	$0.00	$4.34	$4.34
2003	0	0.18	0.18	$0.00	$2.26	$2.26

2004	0	0.10	0.10	$0.00	$1.31	$1.31
2005	0	0.05	0.05	$0.00	$0.61	$0.61
2006	0	0.00	0.00	$0.00	$0.05	$0.05
2007	0	0.00	0.00	$0.00	$0.04	$0.04
2008	0	0.00	0.00	$0.00	$0.00	$0.00

Table 208-15d

Manual Lap Belts Rear Center Seats - LTVs

Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0	0.09	0.09	$0.00	$1.44	$1.44
1969	0	0.09	0.09	$0.00	$1.42	$1.42
1970	0	0.09	0.09	$0.00	$1.40	$1.40
1971	0	0.09	0.09	$0.00	$1.39	$1.39
1972	0	0.09	0.09	$0.00	$1.37	$1.37
1973	0	0.09	0.09	$0.00	$1.36	$1.36
1974	0	0.09	0.09	$0.00	$1.35	$1.35
1975	0	0.09	0.09	$0.00	$1.34	$1.34
1976	0	0.08	0.08	$0.00	$1.34	$1.34
1977	0	0.12	0.12	$0.00	$2.06	$2.06
1978	0	0.11	0.11	$0.00	$2.05	$2.05
1979	0	0.11	0.11	$0.00	$2.04	$2.04
1980	0	0.11	0.11	$0.00	$2.03	$2.03
1981	0	0.11	0.11	$0.00	$2.03	$2.03
1982	0	0.11	0.11	$0.00	$2.02	$2.02
1983	0	0.11	0.11	$0.00	$2.01	$2.01
1984	0	0.12	0.12	$0.00	$2.01	$2.01
1985	0	0.12	0.12	$0.00	$2.00	$2.00
1986	0	0.13	0.13	$0.00	$1.99	$1.99
1987	0	0.24	0.24	$0.00	$3.69	$3.69
1988	0	0.25	0.25	$0.00	$3.68	$3.68
1989	0	0.26	0.26	$0.00	$3.67	$3.67
1990	0	0.27	0.27	$0.00	$3.66	$3.66
1991	0	0.27	0.27	$0.00	$3.65	$3.65
1992	0	0.28	0.28	$0.00	$3.64	$3.64
1993	0	0.28	0.28	$0.00	$3.63	$3.63
1994	0	0.28	0.28	$0.00	$3.62	$3.62
1995	0	0.76	0.76	$0.00	$9.69	$9.69
1996	0	0.76	0.76	$0.00	$9.67	$9.67
1997	0	0.76	0.76	$0.00	$9.65	$9.65

1998	0	0.76	0.76	$0.00	$9.61	$9.61
1999	0	0.75	0.75	$0.00	$9.50	$9.50
2000	0	0.74	0.74	$0.00	$9.38	$9.38
2001	0	0.70	0.70	$0.00	$8.77	$8.77
2002	0	0.57	0.57	$0.00	$7.23	$7.23
2003	0	0.49	0.49	$0.00	$6.21	$6.21
2004	0	0.34	0.34	$0.00	$4.22	$4.22
2005	0	0.23	0.23	$0.00	$2.94	$2.94
2006	0	0.13	0.13	$0.00	$1.63	$1.63
2007	0	0.06	0.06	$0.00	$0.76	$0.76
2008	0	0	0	$0.00	$0.00	$0.00

Table 208-16a
Average Number of Seating Positions and Percentage of Fleet Equipped
Manual Lap/Shoulder Belts in Front Outboard Seats

	PC	**LTV**	**PC**	**LTV**
Model Year	**Number Of Seats**	**Number Of Seats**	**Percent Equipped**	**Percent Equipped**
1968	2	2	87.5	0
1969	2	2	100	2.81
1970	2	2	100	3.21
1971	2	2	100	3.83
1972	2	2	100	5.51
1973	2	2	100	5.4
1974	2	2	100	40.48
1975	2	2	99.57	43.52
1976	2	2	99.65	44.72
1977	2	2	99.59	84.33
1978	2	2	99.59	85.07
1979	2	2	99.51	84.05
1980	2	2	99.44	94.28
1981	2	2	98.97	100
1982	2	2	99.29	100
1983	2	2	99.35	100
1984	2	2	99.67	100
1985	2	2	99.72	100
1986	2	2	99.69	100
1987	2	2	93.37	100
1988	2	2	87.77	100

1989	2	2	83.96	100
1990	2	2	59.88	100
1991	2	2	58.92	100
1992	2	2	71.80	100
1993	2	2	73.49	100
1994	2	2	80.68	100
1995	2	2	93.55	100
1996	2	2	97.31	100
1997	2	2	100	100
1998	2	2	100	100
1999	2	2	100	100
2000	2	2	100	100
2001	2	2	100	100
2002	2	2	100	100
2003	2	2	100	100
2004	2	2	100	100
2005	2	2	100	100
2006	2	2	100	100
2007	2	2	100	100
2008	2	2	100	100
2009	2	2	100	100
2010	2	2	100	100
2011	2	2	100	100
2012	2	2	100	100

Table 208-16b
Weight (lb) and Consumer Cost (2012$)
Manual Lap/Shoulder Belts in Front Outboard Seats

	PC	PC	PC	LTV	LTV	LTV
Model Year	**Cost per Belt**	**Ave. Cost Per Veh.**	**Ave. Weight**	**Cost per Belt**	**Ave. Cost Per Veh.**	**Ave. Weight**
1968	$27.91	$48.84	5.16	$27.20	$0.00	0
1969	$27.91	$55.82	5.90	$27.20	$1.53	0.14
1970	$27.91	$55.82	5.90	$27.20	$1.75	0.16
1971	$27.91	$55.82	5.90	$27.20	$2.08	0.19
1972	$39.66	$79.32	8.68	$47.50	$5.23	0.53
1973	$41.35	$82.70	9.08	$46.91	$5.07	0.52
1974	$45.18	$90.36	9.08	$46.49	$37.64	3.87
1975	$44.99	$89.97	9.55	$46.14	$40.16	4.16
1976	$45.02	$90.04	10.07	$45.78	$40.94	4.28

1977	$44.99	$89.99	10.57	$45.39	$76.56	8.06
1978	$44.99	$89.99	11.08	$45.05	$76.65	8.13
1979	$44.84	$89.68	11.58	$44.77	$75.26	8.04
1980	$44.81	$89.62	11.57	$44.56	$84.02	9.01
1981	$44.60	$89.19	11.52	$44.37	$88.74	9.56
1982	$43.88	$87.75	11.03	$44.20	$88.40	9.56
1983	$43.04	$86.08	10.51	$44.02	$88.04	9.56
1984	$42.31	$84.62	10.02	$43.82	$87.63	9.56
1985	$41.46	$82.93	9.50	$43.61	$87.23	9.56
1986	$40.58	$81.17	8.97	$43.42	$86.84	9.56
1987	$37.20	$74.40	7.91	$43.26	$86.52	9.56
1988	$39.11	$68.65	6.97	$43.11	$86.22	9.56
1989	$39.11	$65.67	6.67	$42.99	$85.97	9.56
1990	$39.11	$46.84	4.75	$42.89	$85.78	9.56
1991	$39.11	$46.09	4.68	$42.81	$85.62	9.56
1992	$39.11	$56.16	5.70	$42.72	$85.44	9.56
1993	$39.02	$57.35	5.84	$42.62	$85.24	9.56
1994	$38.92	$62.80	6.41	$42.51	$85.03	9.56
1995	$38.82	$72.64	7.43	$42.41	$84.81	9.56
1996	$38.72	$75.36	7.73	$42.30	$84.59	9.56
1997	$38.63	$77.25	7.94	$42.19	$84.38	9.56
1998	$38.53	$77.06	7.94	$42.09	$84.17	9.56
1999	$38.43	$76.87	7.94	$41.98	$83.96	9.56
2000	$38.34	$76.67	7.94	$41.87	$83.75	9.56
2001	$38.24	$76.49	7.94	$41.77	$83.55	9.56
2002	$38.16	$76.32	7.94	$41.68	$83.36	9.56
2003	$38.08	$76.15	7.94	$41.59	$83.18	9.56
2004	$38.00	$75.99	7.94	$41.50	$83.01	9.56
2005	$37.92	$75.84	7.94	$41.42	$82.84	9.56
2006	$37.85	$75.69	7.94	$41.34	$82.68	9.56
2007	$37.78	$75.56	7.94	$41.26	$82.53	9.56
2008	$37.72	$75.45	7.94	$41.20	$82.41	9.56
2009	$37.68	$75.36	7.94	$41.16	$82.32	9.56
2010	$37.64	$75.27	7.94	$41.11	$82.22	9.56
2011	$37.59	$75.17	7.94	$41.05	$82.11	9.56
2012	$37.53	$75.06	7.94	$41.00	$81.99	9.56

Table 208-16c						
Manual Lap/Shoulder Belts Front Outboard Seats - Passenger Cars						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	0.01	5.16	5.16	$0.02	$48.82	$48.84
1969	0.01	5.89	5.90	$0.03	$55.79	$55.82
1970	0.01	5.89	5.90	$0.03	$55.79	$55.82
1971	0.01	5.89	5.90	$0.03	$55.79	$55.82
1972	2.81	5.87	8.68	$23.52	$55.79	$79.32
1973	3.21	5.87	9.08	$26.91	$55.79	$82.70
1974	3.33	5.75	9.08	$34.57	$55.79	$90.36
1975	3.32	6.23	9.55	$34.42	$55.55	$89.97
1976	3.32	6.75	10.07	$34.44	$55.60	$90.04
1977	3.32	7.25	10.57	$34.42	$55.57	$89.99
1978	3.33	7.75	11.08	$34.42	$55.57	$89.99
1979	3.33	8.25	11.58	$34.40	$55.28	$89.68
1980	3.33	8.25	11.57	$34.37	$55.24	$89.62
1981	3.31	8.21	11.52	$34.21	$54.98	$89.19
1982	3.32	7.71	11.03	$34.32	$53.43	$87.75
1983	3.32	7.20	10.51	$34.34	$51.74	$86.08
1984	3.32	6.70	10.02	$34.45	$50.17	$84.62
1985	3.32	6.18	9.50	$34.47	$48.46	$82.93
1986	3.32	5.65	8.97	$34.46	$46.71	$81.17
1987	3.10	4.80	7.91	$32.27	$42.12	$74.40
1988	2.55	4.42	6.97	$30.34	$38.32	$68.65
1989	2.44	4.23	6.67	$29.02	$36.65	$65.67
1990	1.74	3.01	4.75	$20.70	$26.14	$46.84
1991	1.71	2.97	4.68	$20.37	$25.72	$46.09
1992	2.09	3.61	5.70	$24.82	$31.34	$56.16
1993	2.14	3.70	5.84	$25.34	$32.01	$57.35
1994	2.34	4.06	6.41	$27.75	$35.05	$62.80
1995	2.72	4.71	7.43	$32.10	$40.54	$72.64
1996	2.83	4.90	7.73	$33.30	$42.06	$75.36
1997	2.91	5.03	7.94	$34.14	$43.11	$77.25
1998	2.91	5.03	7.94	$34.06	$43.01	$77.06
1999	2.91	5.03	7.94	$33.97	$42.90	$76.87
2000	2.91	5.03	7.94	$33.88	$42.79	$76.67
2001	2.91	5.03	7.94	$33.80	$42.69	$76.49
2002	2.91	5.03	7.94	$33.73	$42.59	$76.32
2003	2.91	5.03	7.94	$33.65	$42.50	$76.15

2004	2.91	5.03	7.94	$33.58	$42.41	$75.99
2005	2.91	5.03	7.94	$33.51	$42.32	$75.84
2006	2.91	5.03	7.94	$33.45	$42.24	$75.69
2007	2.91	5.03	7.94	$33.39	$42.17	$75.56
2008	2.91	5.03	7.94	$33.34	$42.11	$75.45
2009	2.91	5.03	7.94	$33.30	$42.06	$75.36
2010	2.91	5.03	7.94	$33.26	$42.01	$75.27
2011	2.91	5.03	7.94	$33.22	$41.95	$75.17
2012	2.91	5.03	7.94	$33.17	$41.89	$75.06

Table 208-16d

FMVSS No. 208 Lap/Shoulder Belts Front Outboard Seats - LTVs

Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	0.00	0.00	0.00	$0.00	$0.00	$0.00
1969	0.02	0.13	0.14	$0.09	$1.43	$1.53
1970	0.02	0.14	0.16	$0.11	$1.64	$1.75
1971	0.02	0.17	0.19	$0.13	$1.95	$2.08
1972	0.03	0.49	0.53	$1.92	$3.31	$5.23
1973	0.27	0.24	0.52	$3.55	$1.52	$5.07
1974	2.05	1.82	3.87	$26.35	$11.29	$37.64
1975	2.20	1.96	4.16	$28.12	$12.04	$40.16
1976	2.26	2.01	4.28	$28.67	$12.28	$40.94
1977	4.27	3.79	8.06	$53.60	$22.96	$76.56
1978	4.30	3.83	8.13	$53.66	$22.98	$76.65
1979	4.25	3.78	8.04	$52.69	$22.57	$75.26
1980	4.77	4.24	9.01	$58.82	$25.19	$84.02
1981	5.06	4.50	9.56	$62.13	$26.61	$88.74
1982	5.06	4.50	9.56	$61.89	$26.51	$88.40
1983	5.06	4.50	9.56	$61.64	$26.40	$88.04
1984	5.06	4.50	9.56	$61.36	$26.28	$87.63
1985	5.06	4.50	9.56	$61.07	$26.16	$87.23
1986	5.06	4.50	9.56	$60.80	$26.04	$86.84
1987	5.06	4.50	9.56	$60.58	$25.94	$86.52
1988	5.06	4.50	9.56	$60.37	$25.86	$86.22
1989	5.06	4.50	9.56	$60.19	$25.78	$85.97
1990	5.06	4.50	9.56	$60.06	$25.72	$85.78
1991	5.06	4.50	9.56	$59.95	$25.67	$85.62
1992	5.06	4.50	9.56	$59.82	$25.62	$85.44

1993	5.06	4.50	9.56	$59.68	$25.56	$85.24
1994	5.06	4.50	9.56	$59.53	$25.50	$85.03
1995	5.06	4.50	9.56	$59.38	$25.43	$84.81
1996	5.06	4.50	9.56	$59.23	$25.37	$84.59
1997	5.06	4.50	9.56	$59.08	$25.30	$84.38
1998	5.06	4.50	9.56	$58.93	$25.24	$84.17
1999	5.06	4.50	9.56	$58.78	$25.18	$83.96
2000	5.06	4.50	9.56	$58.64	$25.11	$83.75
2001	5.06	4.50	9.56	$58.50	$25.05	$83.55
2002	5.06	4.50	9.56	$58.36	$25.00	$83.36
2003	5.06	4.50	9.56	$58.24	$24.94	$83.18
2004	5.06	4.50	9.56	$58.12	$24.89	$83.01
2005	5.06	4.50	9.56	$58.00	$24.84	$82.84
2006	5.06	4.50	9.56	$57.89	$24.79	$82.68
2007	5.06	4.50	9.56	$57.78	$24.75	$82.53
2008	5.06	4.50	9.56	$57.70	$24.71	$82.41
2009	5.06	4.50	9.56	$57.63	$24.68	$82.32
2010	5.06	4.50	9.56	$57.56	$24.65	$82.22
2011	5.06	4.50	9.56	$57.49	$24.62	$82.11
2012	5.06	4.50	9.56	$57.41	$24.59	$81.99

Table 208-17a
Average Number of Seating Positions and Percentage of Fleet Equipped
Manual Lap/Shoulder Belts in Rear Outboard Seats

	PC	LTV	PC	LTV
Model Year	**Number Of Seats**	**Number Of Seats**	**Percent Equipped**	**Percent Equipped**
1968	1.98	0.39	0	0
1969	1.98	0.39	0	0
1970	1.98	0.39	0	0
1971	1.98	0.39	0.45	0
1972	1.98	0.39	0.38	0
1973	1.98	0.39	0.35	0
1974	1.98	0.39	0.61	0
1975	1.98	0.39	0.96	0
1976	1.98	0.39	0.74	0
1977	1.96	0.83	0.54	0

1978	1.96	0.83	0.61	0
1979	1.96	0.83	0.64	0
1980	1.96	0.83	0.74	0
1981	1.96	0.83	1.71	0
1982	1.96	0.83	4.08	0
1983	1.96	0.83	5.82	0
1984	1.96	0.83	5.55	0
1985	1.96	0.83	5.75	0
1986	1.96	0.83	6.86	0
1987	1.97	1.31	9.62	0.29
1988	1.97	1.31	30.67	2.84
1989	1.97	1.31	67.67	16.8
1990	1.96	1.31	100	20.01
1991	1.96	1.31	100	32.25
1992	1.96	1.31	100	100
1993	1.96	1.31	100	100
1994	1.96	1.31	100	100
1995	1.97	2.21	100	100
1996	1.97	2.21	100	100
1997	1.97	2.21	100	100
1998	1.97	2.21	100	100
1999	1.97	2.21	100	100
2000	1.97	2.21	100	100
2001	1.97	2.21	100	100
2002	1.97	2.21	100	100
2003	1.96	2.32	100	100
2004	1.96	2.32	100	100
2005	1.96	2.32	100	100
2006	1.96	2.32	100	100
2007	1.96	2.32	100	100
2008	1.99	2.34	100	100
2009	1.99	2.34	100	100
2010	1.99	2.34	100	100
2011	1.99	2.34	100	100
2012	1.99	2.34	100	100

Table 208-17b						
Weight (lb) and Consumer Cost (2012$)						
Manual Lap/Shoulder Belts in Rear Outboard Seats						
	PC	PC	PC	LTV	LTV	LTV
Model Year	Cost per Belt	Ave. Cost Per Veh.	Ave. Weight	Cost per Belt	Ave. Cost Per Veh.	Ave. Weight
1968	$0.00	$0.00	0	$0.00	$0.00	0
1969	$0.00	$0.00	0	$0.00	$0.00	0
1970	$0.00	$0.00	0	$0.00	$0.00	0
1971	$20.31	$0.18	0.02	$0.00	$0.00	0
1972	$31.83	$0.24	0.02	$0.00	$0.00	0
1973	$31.11	$0.22	0.02	$0.00	$0.00	0
1974	$30.46	$0.37	0.03	$0.00	$0.00	0
1975	$29.79	$0.57	0.05	$0.00	$0.00	0
1976	$29.35	$0.43	0.04	$0.00	$0.00	0
1977	$29.07	$0.31	0.03	$0.00	$0.00	0
1978	$28.80	$0.34	0.03	$0.00	$0.00	0
1979	$28.56	$0.36	0.03	$0.00	$0.00	0
1980	$28.37	$0.41	0.04	$0.00	$0.00	0
1981	$28.01	$0.94	0.09	$0.00	$0.00	0
1982	$27.42	$2.19	0.21	$0.00	$0.00	0
1983	$26.77	$3.05	0.29	$0.00	$0.00	0
1984	$26.29	$2.86	0.28	$0.00	$0.00	0
1985	$25.90	$2.92	0.29	$0.00	$0.00	0
1986	$25.53	$3.43	0.35	$0.00	$0.00	0
1987	$25.16	$4.77	0.49	$25.16	$0.10	0.01
1988	$24.36	$14.72	1.56	$24.36	$0.91	0.10
1989	$23.43	$31.24	3.44	$23.43	$5.16	0.57
1990	$22.74	$44.57	5.05	$22.74	$5.96	0.68
1991	$22.32	$43.75	5.05	$22.32	$9.43	1.09
1992	$21.92	$42.96	5.05	$21.92	$28.71	3.38
1993	$21.59	$42.32	5.05	$21.59	$28.28	3.38
1994	$21.32	$41.78	5.05	$21.32	$27.92	3.38
1995	$21.10	$41.56	5.08	$21.10	$46.62	5.70
1996	$20.91	$41.19	5.08	$20.91	$46.21	5.70
1997	$20.75	$40.87	5.08	$20.75	$45.85	5.70
1998	$20.60	$40.58	5.08	$20.60	$45.52	5.70
1999	$20.46	$40.30	5.08	$20.46	$45.21	5.70
2000	$20.33	$40.05	5.08	$20.33	$44.93	5.70
2001	$20.22	$39.83	5.08	$20.22	$44.68	5.70

2002	$20.12	$39.63	5.08	$20.12	$44.46	5.70
2003	$20.02	$39.24	5.05	$20.02	$46.47	5.99
2004	$19.94	$39.07	5.05	$19.94	$46.27	5.99
2005	$19.86	$38.91	5.05	$19.86	$46.08	5.99
2006	$19.79	$38.77	5.05	$19.79	$45.91	5.99
2007	$19.72	$38.64	5.05	$19.72	$45.76	5.99
2008	$19.67	$39.05	5.12	$19.67	$45.96	6.03
2009	$19.63	$38.97	5.12	$19.63	$45.87	6.03
2010	$19.59	$38.89	5.12	$19.59	$45.77	6.03
2011	$19.54	$38.80	5.12	$19.54	$45.67	6.03
2012	$19.49	$38.71	5.12	$19.49	$45.55	6.03

Table 208-17c
Weight (lb) and Consumer Cost (2012$)
Manual Lap/Shoulder Belts for Rear Seat Outboard - Passenger Cars

Model Year	Weight (lb)			Consumer Cost (2012$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0.00	0.00	0.00	$0.00	$0.00	$0.00
1969	0.00	0.00	0.00	$0.00	$0.00	$0.00
1970	0.00	0.00	0.00	$0.00	$0.00	$0.00
1971	0.00	0.02	0.02	$0.00	$0.18	$0.18
1972	0.00	0.02	0.02	$0.06	$0.18	$0.24
1973	0.00	0.02	0.02	$0.05	$0.17	$0.22
1974	0.00	0.03	0.03	$0.08	$0.29	$0.37
1975	0.00	0.05	0.05	$0.11	$0.45	$0.57
1976	0.00	0.04	0.04	$0.08	$0.35	$0.43
1977	0.00	0.03	0.03	$0.06	$0.25	$0.31
1978	0.00	0.03	0.03	$0.06	$0.28	$0.34
1979	0.00	0.03	0.03	$0.07	$0.29	$0.36
1980	0.00	0.04	0.04	$0.07	$0.34	$0.41
1981	0.00	0.09	0.09	$0.16	$0.78	$0.94
1982	0.00	0.21	0.21	$0.34	$1.85	$2.19
1983	0.00	0.29	0.29	$0.42	$2.63	$3.05
1984	0.00	0.28	0.28	$0.36	$2.50	$2.86
1985	0.00	0.29	0.29	$0.34	$2.58	$2.92
1986	0.00	0.35	0.35	$0.36	$3.07	$3.43
1987	0.00	0.49	0.49	$0.48	$4.29	$4.77
1988	0.00	1.56	1.56	$1.08	$13.64	$14.72
1989	0.00	3.44	3.44	$1.19	$30.05	$31.24
1990	1.09	3.96	5.05	$1.15	$43.43	$44.57

1991	1.09	3.96	5.05	$1.13	$42.63	$43.75
1992	1.09	3.96	5.05	$1.10	$41.85	$42.96
1993	1.09	3.96	5.05	$1.09	$41.23	$42.32
1994	1.09	3.96	5.05	$1.07	$40.70	$41.78
1995	1.11	3.97	5.08	$1.07	$40.49	$41.56
1996	1.11	3.97	5.08	$1.06	$40.13	$41.19
1997	1.11	3.97	5.08	$1.05	$39.82	$40.87
1998	1.11	3.97	5.08	$1.04	$39.54	$40.58
1999	1.11	3.97	5.08	$1.04	$39.27	$40.30
2000	1.11	3.97	5.08	$1.03	$39.02	$40.05
2001	1.11	3.97	5.08	$1.02	$38.80	$39.83
2002	1.11	3.97	5.08	$1.02	$38.61	$39.63
2003	1.09	3.96	5.05	$1.01	$38.23	$39.24
2004	1.09	3.96	5.05	$1.00	$38.07	$39.07
2005	1.09	3.96	5.05	$1.00	$37.91	$38.91
2006	1.09	3.96	5.05	$1.00	$37.77	$38.77
2007	1.09	3.96	5.05	$0.99	$37.65	$38.64
2008	1.14	3.98	5.12	$1.00	$38.05	$39.05
2009	1.14	3.98	5.12	$1.00	$37.97	$38.97
2010	1.14	3.98	5.12	$1.00	$37.89	$38.89
2011	1.14	3.98	5.12	$1.00	$37.80	$38.80
2012	1.14	3.98	5.12	$1.00	$37.71	$38.71

Table 208-17d						
FMVSS No. 208 Lap/Shoulder Belts Rear Outboard Seats - LTVs						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	0.00	0.00	0.00	$0.00	$0.00	$0.00
1969	0.00	0.00	0.00	$0.00	$0.00	$0.00
1970	0.00	0.00	0.00	$0.00	$0.00	$0.00
1971	0.00	0.00	0.00	$0.00	$0.00	$0.00
1972	0.00	0.00	0.00	$0.00	$0.00	$0.00
1973	0.00	0.00	0.00	$0.00	$0.00	$0.00
1974	0.00	0.00	0.00	$0.00	$0.00	$0.00
1975	0.00	0.00	0.00	$0.00	$0.00	$0.00
1976	0.00	0.00	0.00	$0.00	$0.00	$0.00
1977	0.00	0.00	0.00	$0.00	$0.00	$0.00
1978	0.00	0.00	0.00	$0.00	$0.00	$0.00
1979	0.00	0.00	0.00	$0.00	$0.00	$0.00
1980	0.00	0.00	0.00	$0.00	$0.00	$0.00
1981	0.00	0.00	0.00	$0.00	$0.00	$0.00
1982	0.00	0.00	0.00	$0.00	$0.00	$0.00
1983	0.00	0.00	0.00	$0.00	$0.00	$0.00
1984	0.00	0.00	0.00	$0.00	$0.00	$0.00
1985	0.00	0.00	0.00	$0.00	$0.00	$0.00
1986	0.00	0.00	0.00	$0.00	$0.00	$0.00
1987	0.00	0.01	0.01	$0.01	$0.09	$0.10
1988	0.00	0.10	0.10	$0.06	$0.84	$0.91
1989	0.00	0.57	0.57	$0.17	$4.99	$5.16
1990	0.02	0.66	0.68	$0.31	$5.66	$5.96
1991	0.09	1.00	1.09	$0.89	$8.54	$9.43
1992	0.47	2.91	3.38	$4.13	$24.58	$28.71
1993	0.47	2.91	3.38	$4.06	$24.23	$28.28
1994	0.47	2.91	3.38	$4.00	$23.93	$27.92
1995	0.86	4.84	5.70	$7.14	$39.49	$46.62
1996	0.86	4.84	5.70	$7.07	$39.14	$46.21
1997	0.86	4.84	5.70	$7.01	$38.84	$45.85
1998	0.86	4.84	5.70	$6.95	$38.57	$45.52
1999	0.86	4.84	5.70	$6.90	$38.31	$45.21
2000	0.86	4.84	5.70	$6.85	$38.08	$44.93
2001	0.86	4.84	5.70	$6.81	$37.87	$44.68
2002	0.86	4.84	5.70	$6.77	$37.68	$44.46
2003	0.91	5.08	5.99	$7.11	$39.36	$46.47

2004	0.91	5.08	5.99	$7.08	$39.19	$46.27
2005	0.91	5.08	5.99	$7.05	$39.03	$46.08
2006	0.91	5.08	5.99	$7.02	$38.89	$45.91
2007	0.91	5.08	5.99	$6.99	$38.76	$45.76
2008	0.92	5.11	6.03	$7.03	$38.93	$45.96
2009	0.92	5.11	6.03	$7.01	$38.86	$45.87
2010	0.92	5.11	6.03	$6.99	$38.78	$45.77
2011	0.92	5.11	6.03	$6.98	$38.69	$45.67
2012	0.92	5.11	6.03	$6.96	$38.60	$45.55

Table 208-18a
Average Number of Seating Positions and
Percentage of Fleet Equipped
Manual Lap/Shoulder Belts in Rear Center Seats

	PC	**LTV**	**PC**	**LTV**
Model Year	**Number Of Seats**	**Number Of Seats**	**Percent Equipped**	**Percent Equipped**
1993	0.86	0.26	0	0
1994	0.86	0.26	0.49	0
1995	0.90	0.70	0.56	0
1996	0.90	0.70	1.68	0
1997	0.90	0.70	11.60	0
1998	0.90	0.70	26.63	0.23
1999	0.90	0.70	30.86	1.17
2000	0.90	0.70	43.00	2.22
2001	0.90	0.70	59.59	8.47
2002	0.90	0.70	64.86	24.52
2003	0.92	0.94	82.13	51.75
2004	0.92	0.94	89.60	67.20
2005	0.92	0.94	95.15	77.14
2006	0.92	0.94	99.60	87.30
2007	0.92	0.94	99.71	94.06
2008	0.93	0.97	100	100
2009	0.93	0.97	100	100
2010	0.93	0.97	100	100
2011	0.93	0.97	100	100
2012	0.93	0.97	100	100

Table 208-18b						
Weight (lb) and Consumer Cost (2012$)						
Manual Lap/Shoulder Belts in Rear Center Seats						
	PC	**PC**	**PC**	**LTV**	**LTV**	**LTV**
Model Year	**Cost per Belt**	**Ave. Cost Per Veh.**	**Ave. Weight**	**Cost per Belt**	**Ave. Cost Per Veh.**	**Ave. Weight**
1993	$0.00	$0.00	0.00			
1994	$40.34	$0.17	0.01			
1995	$38.62	$0.19	0.02			
1996	$36.55	$0.55	0.05			
1997	$33.22	$3.47	0.32	$0.00	$0.00	0.00
1998	$31.25	$7.49	0.73	$31.25	$0.05	0.00
1999	$30.17	$8.38	0.84	$30.17	$0.25	0.02
2000	$29.29	$11.34	1.17	$29.29	$0.45	0.05
2001	$28.53	$15.30	1.63	$28.53	$1.68	0.18
2002	$27.89	$16.28	1.77	$27.89	$4.77	0.52
2003	$27.26	$20.59	2.29	$27.26	$13.22	1.47
2004	$26.75	$22.04	2.50	$26.75	$16.85	1.91
2005	$26.33	$23.04	2.65	$26.33	$19.04	2.19
2006	$25.99	$23.81	2.78	$25.99	$21.26	2.48
2007	$25.71	$23.57	2.78	$25.71	$22.66	2.67
2008	$25.51	$23.64	2.81	$25.51	$24.79	2.94
2009	$25.37	$23.51	2.81	$25.37	$24.65	2.94
2010	$25.22	$23.38	2.81	$25.22	$24.51	2.94
2011	$25.08	$23.25	2.81	$25.08	$24.38	2.94
2012	$24.94	$23.11	2.81	$24.94	$24.24	2.94

Table 208-18c						
Weight (lb) and Consumer Cost (2012$)						
Manual Lap/Shoulder Belts for Rear Center Seat - Passenger Cars						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1993	0.00	0.00	0.00	$0.00	$0.00	$0.00
1994	0.01	0.00	0.01	$0.11	$0.06	$0.17
1995	0.01	0.01	0.02	$0.12	$0.07	$0.19
1996	0.03	0.02	0.05	$0.34	$0.21	$0.55
1997	0.20	0.11	0.32	$2.02	$1.45	$3.47
1998	0.46	0.26	0.73	$4.18	$3.31	$7.49
1999	0.54	0.30	0.84	$4.55	$3.83	$8.38
2000	0.75	0.42	1.17	$6.01	$5.33	$11.34
2001	1.04	0.58	1.63	$7.92	$7.37	$15.30
2002	1.13	0.64	1.77	$8.26	$8.02	$16.28
2003	1.47	0.82	2.29	$10.23	$10.37	$20.59
2004	1.49	1.01	2.50	$10.61	$11.44	$22.04
2005	1.48	1.17	2.65	$10.91	$12.14	$23.04
2006	1.47	1.31	2.78	$11.11	$12.70	$23.81
2007	1.47	1.31	2.78	$10.87	$12.71	$23.57
2008	1.48	1.33	2.81	$10.80	$12.84	$23.64
2009	1.48	1.33	2.81	$10.67	$12.84	$23.51
2010	1.48	1.33	2.81	$10.54	$12.84	$23.38
2011	1.48	1.33	2.81	$10.41	$12.84	$23.25
2012	1.48	1.33	2.81	$10.28	$12.83	$23.11

Table 208-18d						
FMVSS No. 208 Lap/Shoulder Belts Rear Center Seat - LTVs						
Model	**Weight (lb)**			**Consumer Cost (2012$)**		
Year	**Voluntary**	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1997	0	0	0	0	0	0
1998	0.00	0.00	0.00	$0.03	$0.02	$0.05
1999	0.02	0.01	0.02	$0.13	$0.11	$0.25
2000	0.03	0.02	0.05	$0.24	$0.21	$0.45
2001	0.11	0.06	0.18	$0.87	$0.81	$1.68
2002	0.33	0.19	0.52	$2.42	$2.35	$4.77
2003	0.94	0.53	1.47	$6.57	$6.66	$13.22
2004	1.08	0.82	1.91	$6.32	$10.53	$16.85
2005	1.11	1.08	2.19	$6.12	$12.92	$19.04
2006	1.07	1.41	2.48	$5.95	$15.31	$21.26
2007	1.01	1.66	2.67	$5.82	$16.84	$22.66
2008	0.98	1.97	2.94	$5.93	$18.86	$24.79
2009	0.98	1.97	2.94	$5.86	$18.79	$24.65
2010	0.98	1.97	2.94	$5.79	$18.72	$24.51
2011	0.98	1.97	2.94	$5.72	$18.66	$24.38
2012	0.98	1.97	2.94	$5.65	$18.59	$24.24

Table 208-19a					
Average Number of Seating Positions, Percentage of Fleet Equipped,					
And Costs of Automatic Seat Belts in Front Outboard Seats					
	PC	LTV	Ave. PC	PC	PC
Model Year	Percent Equipped	Percent Equipped	Cost per Belt	Ave. Cost Per Veh.	Ave. Weight
1968	0	0	0	0	0
1969	0	0	0	0	0
1970	0	0	0	0	0
1971	0	0	0	0	0
1972	0	0	0	0	0
1973	0	0	0	0	0
1974	0	0	0	0	0
1975	0.43	0	$89.12	$0.77	0.10
1976	0.35	0	$89.12	$0.62	0.08
1977	0.41	0	$89.12	$0.73	0.10
1978	0.41	0	$89.12	$0.73	0.10
1979	0.49	0	$89.12	$0.87	0.12
1980	0.56	0	$89.12	$1.00	0.13
1981	1.03	0	$156.96	$3.23	0.29
1982	0.71	0	$156.96	$2.23	0.20
1983	0.65	0	$224.80	$2.92	0.21
1984	0.33	0	$224.80	$1.48	0.11
1985	0.28	0	$224.80	$1.26	0.09
1986	0.31	0	$224.80	$1.39	0.10
1987	6.63	0	$209.70	$27.81	2.10
1988	12.23	0	$208.58	$51.02	3.84
1989	16.04	0	$211.09	$67.72	4.99
1990	40.12	0	$209.14	$167.81	12.64
1991	41.08	0	$198.95	$163.46	11.92
1992	28.2	0	$190.15	$107.24	7.86
1993	26.51	0	$206.47	$109.47	7.96
1994	19.32	0	$190.74	$73.70	5.37
1995	6.45	0	$208.26	$26.87	1.96
1996	2.69	0	$210.66	$11.33	0.83
1997	0	0	0	0	0

Table 208-19b						
Weight (lb) and Consumer Cost (2012$)						
Automatic Belts Front Outboard Seats - Passenger Cars						
Model	**Weight (lb)**			**Consumer Cost (2012$)**		
Year	**Voluntary**	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	0.00	0.00	0.00	$0.00	$0.00	$0.00
1969	0.00	0.00	0.00	$0.00	$0.00	$0.00
1970	0.00	0.00	0.00	$0.00	$0.00	$0.00
1971	0.00	0.00	0.00	$0.00	$0.00	$0.00
1972	0.00	0.00	0.00	$0.00	$0.00	$0.00
1973	0.00	0.00	0.00	$0.00	$0.00	$0.00
1974	0.00	0.00	0.00	$0.00	$0.00	$0.00
1975	0.07	0.04	0.10	$0.44	$0.33	$0.77
1976	0.05	0.03	0.08	$0.36	$0.27	$0.62
1977	0.06	0.03	0.10	$0.42	$0.31	$0.73
1978	0.06	0.03	0.10	$0.42	$0.31	$0.73
1979	0.07	0.04	0.12	$0.50	$0.38	$0.87
1980	0.09	0.05	0.13	$0.57	$0.43	$1.00
1981	0.20	0.09	0.29	$2.44	$0.79	$3.23
1982	0.14	0.06	0.20	$1.68	$0.54	$2.23
1983	0.15	0.05	0.21	$2.42	$0.50	$2.92
1984	0.08	0.03	0.11	$1.23	$0.25	$1.48
1985	0.00	0.09	0.09	$0.00	$1.26	$1.26
1986	0.00	0.10	0.10	$0.00	$1.39	$1.39
1987	0.01	2.09	2.10	$0.07	$27.73	$27.81
1988	0.01	3.83	3.84	$0.14	$50.88	$51.02
1989	0.01	4.98	4.99	$0.18	$67.54	$67.72
1990	0.03	12.61	12.64	$0.45	$167.36	$167.81
1991	0.03	11.89	11.92	$0.44	$163.02	$163.46
1992	0.02	7.85	7.86	$0.28	$106.96	$107.24
1993	0.02	7.94	7.96	$0.29	$109.18	$109.47
1994	0.01	5.36	5.37	$0.19	$73.51	$73.70
1995	0.00	1.96	1.96	$0.07	$26.79	$26.87
1996	0.00	0.83	0.83	$0.03	$11.30	$11.33
1997	0.00	0.00	0.00	$0.00	$0.00	$0.00

Pretensioners, Load Limiters, and Adjustable Anchors

While seat belts reduce the risk of fatal and serious injuries, rib and abdominal injuries may be suffered in high-speed collisions especially if the seat belt is not correctly positioned. These risks are minimized with seat belt pretensioners, load limiters, and adjustable anchors. These three safety features are discussed together since they were introduced into the fleet at essentially the same time period and they all are related to seat belts. Adjustable anchors are required in FMVSS No. 208 (see S7.1.2). The upper torso restraint shall include a movable component which has a minimum of two adjustment positions. Although pretensioners and load limiters are not mandatory for meeting NHTSA standards, NHTSA regards them with favor and provides consumer information on their availability. Certainly the required frontal air bags allow the load limiters to optimize the load sharing between the seat belt and air bag.

Pretensioners. There have been a variety of pretensioners used that work in somewhat similar ways. Some pretensioners just lock the seat belt webbing and don't allow it to extend further. The more effective systems tighten the seat belt webbing. In a crash, the air bag sensors and air bag ignition circuits are typically used to determine the level of deceleration and to determine when to engage the pretensioners. Pretensioners retract the seat belt almost instantly to remove excess slack and keep the occupant restrained. Excessive slack allows too much occupant motion during a crash, thus increasing the chance of contact with components such as the steering wheel, dashboard, or windshield and the possibility of increased potential of injury in an accident. The three types of pretensioners that have been used include mechanical, electrical, and mostly pyrotechnic. Mechanical pretensioners use preloaded springs that are released mechanically or by an inertial wheel and a pendulum system to lock the webbing. Electrical pretensioners replace the mechanical means with an electrical motor to tighten the webbing. Pyrotechnic pretensioners fire a pyrotechnic device to tighten the seat belt a prescribed amount upon sensing a crash event. This keeps the occupant travel to a minimum and also helps optimize occupant position for effective use of the restraint capabilities of the air bag systems.

Load Limiters. In severe crashes where a car collides with an obstacle at extremely high speed, a seat belt can inflict injury to the occupant as it exerts the necessary force to restrain them. As a passenger's inertial speed increases, it takes a greater force to bring the passenger to a stop, i.e., the faster you are going upon impact, the harder you will move into the seat belt. When forces on the shoulder belt rise above a predetermined level, load limiters allow the belt to give or yield while controlling the tension in the belt, typically by spooling it out of the retractor, to avoid concentrating too much force on the occupant's chest. Load limiters in recent vehicles typically use a torsion bar built into the seat belt retractor. The torsion bar is a metal rod that will twist when sufficient torque is applied. In minor collisions, the torsion bar will hold its shape and the seat belt retractor will lock normally. But, when the force applied by the webbing reaches the design limit, the torsion bar twists and allows the webbing to spool out of the retractor.

Adjustable Anchors. An adjustable upper belt anchor improves the seat belt's protective effect by letting the occupant change the position of the shoulder strap to accommodate that person's size, which increases the ease and comfort of seat belt use for car occupants of above or below average height. The NPRM for adjustable anchors was published in the Federal Register (59 FR 21740) on April 26, 1994, making the baseline date September 1, 1993, or MY 1994. The effective date of the final rule was September 1, 1997, or MY 1998. Since 100 percent of the fleet did not have adjustable anchors by the baseline date, adjustable anchor costs will be considered voluntary through MY 1994 and the voluntary percentage will be held at that MY 1994 baseline level through MY 2012. Attributable costs will be the difference between the installation rates for MY 1995 to MY 2012 minus the voluntary baseline level of MY 1994.

A study was conducted in 2000 on fourteen 1992- to 1999 make-model passenger vehicles, including nine vehicles equipped with pretensioners, load limiters, adjustable anchors, or a combination of these technologies and five baseline vehicles, to determine the weight and consumer cost of pretensioners, load limiters, and adjustable anchors.[149] Four of the MY 1999 vehicles had pyrotechnic pretensioners and four did not and the average cost for both sets was almost identical. Thus, we considered both types of pretensioners together. Table 208-20 shows the arithmetic average weight and consumer cost of all three technologies. This is before considering the learning curve.

TABLE 208-20
AVERAGE WEIGHT AND CONSUMER COST PER SEAT
OF PRETENSIONERS, LOAD LIMITERS, AND ADJUSTABLE ANCHORS

COMPONENT	WEIGHT IN POUNDS	CONSUMER COST ($2012)
Pretensioners	0.16	$15.74
Load Limiters	0.33	$5.80
Adjustable Anchors	0.65	$4.36
TOTAL FOR ALL THREE	1.14	$25.89

Pretensioners and load limiters are voluntarily installed in passenger vehicles by the automotive manufacturers and not required by NHTSA, their costs are not attributed to FMVSS No. 208, but are included in the voluntary totals. NHTSA has never required installation of these technologies, but encouraged it by listing the makes and models of vehicles that offer them in its annual *Buying a Safer Car* brochures from 1997[150] and, subsequently, on the Internet at www.safercar.gov. Furthermore, addition of these technologies usually improved vehicles' performance on NHTSA's NCAP tests. Mercedes-Benz introduced pretensioners in the front seats of their S-class cars in 1981. The introduction of pretensioners in the front seat was spread over many years, although most models received them sometime between 1998 and 2006. Front seat pretensioners were in 55 percent of both passenger cars and LTVs by MY 2002.

Only Volvo and Mercedes have introduced pretensioners in the rear seat of some of their passenger car models (Volvo in MY 1999 and Mercedes in MY 2000). Volvo extended the use of pretensioners to LTVs in MY 2000 and Mercedes in MY 2007. Combined passenger car rear seat pretensioners never exceeded 3.5 percent of passenger car sales and rose to 0.8 percent of LTV sales by MY 2012. Models with pretensioners in the rear seat were found by examining cars.com, "read specs. & reviews" tab, searching for a particular model and model year, then

[149] Khadilkar, Fladmark, & Khadilkar, DOT HS 809 806 and DOT HS 809 807, 2001). Docket No. 2011-0066-0015 and 0016. The buckle weights and costs were taken out of the calculations for Table 208-10.
[150] Available for 2000 to 2005 at icsw.nhtsa.gov/safe_car_new/ (click on SaferCar2000, SaferCar2001, BASC2002, BASC2003, BASC2004, or BASC2005) and for 2006 to 2010 at www.safercar.gov/Vehicle+Shoppers/Resources/Buying+a+Safer+Car+brochures.

"features & specs.," clicking on specifications, and then finally searching the active and passive safety section for front and rear pretensioners.

Volvo introduced load limiters on its 850 series in 1995. Load limiters mostly entered the new-vehicle fleet between 1997 and 2002. By MY 2002, 91 percent of new cars and 75 percent of new LTVs were already being equipped with load limiters at the outboard front seats. All new passenger cars and LTVs were equipped with pretensioners and load limiters by MY 2008 at the outboard front seating positions. Estimates of load limiters sales were developed by taking load limiter information by make/model in the appendix of the evaluation and weighting them by Wards sales data.[151]

On December 12, 1990, the National Transportation Safety Board recommended that manufacturers of passenger vehicles provide an adjustable upper anchorage for the shoulder portion of the seat belts. See www.ntsb.gov/about/employment/_layouts/ntsb.recsearch/Recommendation.aspx?Rec=H-90-111. The manufacturers responded to NTSB with their plans to include adjustable upper anchors in their vehicles by model year. Many of the manufacturers were only planning to include adjustable anchors for 4-door passenger cars, but some included certain LTVs. Many manufacturers believed that because the anchorage point was far behind the driver for a 2-door vehicle that the adjustability of the anchorage point was of little value to the driver. These plans, which are provided in the same cite above, were combined with sales data to form the basis of our estimates of the percentage of the fleet provided with adjustable anchors. The earliest information we found was that the Jaguar sedans had adjustable anchors in MY 1987. Because they make up such a small percentage of the new car fleet, we started the table in MY 1989. NHTSA later proposed that all passenger cars and LTVs be required to have adjustable anchors.

Table 208-21a shows the estimated percent of the fleet and the associated weight and consumer cost for front seat pretensioners. Table 208-21b shows the same information for rear seat pretensioners. Table 208-21c shows the estimated percent of the fleet and the associated weight and consumer cost for front seat load limiters and Table 208-21d shows the same information for front seat adjustable anchors. The estimated cost for passenger cars and LTVs is shown after applying the learning curve, which uses the seat belt progress rate of 0.96.

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[151] Kahane, C. J. (2013, November). *Effectiveness of pretensioners and load limiters for enhancing fatality reduction by seat belts.* (Report No. DOT HS 811 835). Washington, DC: National Highway Traffic Safety Administration. Available at www-nrd.nhtsa.dot.gov/Pubs/811835.pdf

Table 208-21a

Average Weight and Cost (2012$) for Voluntarily Supplied Front Seat Pretensioners

Model Year	PC Percent	PC Weight	PC Cost	LTV Percent	LTV Weight	LTV Cost
1995	0.27	0.00	$0.11	0.01	0.00	$0.00
1996	0.51	0.00	$0.20	0	0.00	$0.00
1997	1.01	0.00	$0.38	0.02	0.00	$0.01
1998	10.67	0.03	$3.55	3.03	0.01	$1.01
1999	13.84	0.04	$4.36	8.38	0.03	$2.64
2000	30.04	0.10	$9.03	12.64	0.04	$3.80
2001	49.87	0.16	$14.35	38.56	0.12	$11.09
2002	55.11	0.18	$15.39	55.72	0.18	$15.56
2003	62.11	0.20	$16.99	60.91	0.19	$16.66
2004	70.62	0.23	$18.98	68.92	0.22	$18.52
2005	79.05	0.25	$20.92	81.45	0.26	$21.56
2006	99.57	0.32	$26.00	84.53	0.27	$22.07
2007	100	0.32	$25.82	93.42	0.30	$24.13
2008	100	0.32	$25.62	100	0.32	$25.62
2009	100	0.32	$25.47	100	0.32	$25.47
2010	100	0.32	$25.33	100	0.32	$25.33
2011	100	0.32	$25.18	100	0.32	$25.18
2012	100	0.32	$25.04	100	0.32	$25.04

Table 208-21b						
Average Weight and Cost (2012$) for Voluntarily Supplied						
Rear Seat Pretensioners						
Model Year	**PC Percent**	**PC Weight**	**PC Cost**	**LTV Percent**	**LTV Weight**	**LTV Cost**
1998	0	0.00	$0.00	0	0.00	$0.00
1999	0.19	0.00	$0.06	0	0.00	$0.00
2000	1.48	0.00	$0.44	0.19	0.00	$0.06
2001	2.11	0.01	$0.61	0.19	0.00	$0.05
2002	2.46	0.01	$0.69	0.51	0.00	$0.14
2003	2.58	0.01	$0.70	0.51	0.00	$0.14
2004	3.32	0.01	$0.89	0.59	0.00	$0.16
2005	3.33	0.01	$0.88	0.57	0.00	$0.15
2006	3.28	0.01	$0.86	0.33	0.00	$0.09
2007	3.11	0.01	$0.80	0.52	0.00	$0.13
2008	3.39	0.01	$0.87	0.55	0.00	$0.14
2009	2.91	0.01	$0.74	0.36	0.00	$0.09
2010	2.91	0.01	$0.74	0.50	0.00	$0.13
2011	2.92	0.01	$0.74	0.80	0.00	$0.20
2012	2.77	0.01	$0.69	0.83	0.00	$0.21

Table 208-21c						
Average Weight and Cost (2012$) for Voluntarily Supplied Front Seat Load Limiters						
Model Year	**PC Percent**	**PC Weight**	**PC Cost**	**LTV Percent**	**LTV Weight**	**LTV Cost**
1994	0	0.00	$0.00	0	0.00	$0.00
1995	0.17	0.00	$0.03	0	0.00	$0.00
1996	0.18	0.00	$0.03	0	0.00	$0.00
1997	2.25	0.01	$0.32	1.97	0.01	$0.28
1998	9.22	0.06	$1.18	8.61	0.06	$1.10
1999	55.77	0.37	$6.47	28.73	0.19	$3.33
2000	67.57	0.45	$7.50	44.23	0.29	$4.91
2001	79.37	0.52	$8.56	59.73	0.39	$6.44
2002	91.20	0.60	$9.62	75.18	0.50	$7.93
2003	92.08	0.61	$9.56	77.66	0.51	$8.06
2004	96.48	0.64	$9.88	79.57	0.53	$8.15
2005	97.74	0.65	$9.90	84.31	0.56	$8.54
2006	99.57	0.66	$9.99	83.32	0.55	$8.36
2007	99.56	0.66	$9.91	100	0.66	$9.95
2008	100	0.66	$9.89	100	0.66	$9.89
2009	100	0.66	$9.85	100	0.66	$9.85
2010	100	0.66	$9.80	100	0.66	$9.80
2011	100	0.66	$9.75	100	0.66	$9.75
2012	100	0.66	$9.71	100	0.66	$9.71

Table 208-21d Average Weight and Cost (2012$) for Front Seat Adjustable Anchors Passenger Cars							
Model Year	**Percent Installed**	**Weight (lb)**			**Consumer Cost (2012$)**		
		Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1989	0.51	0.01	0.00	0.01	$0.07	$0.00	$0.07
1990	0.51	0.01	0.00	0.01	$0.06	$0.00	$0.06
1991	1.79	0.02	0.00	0.02	$0.21	$0.00	$0.21
1992	13.71	0.18	0.00	0.18	$1.49	$0.00	$1.49
1993	21.97	0.29	0.00	0.29	$2.24	$0.00	$2.24
1994	30.99	0.40	0.00	0.40	$3.05	$0.00	$3.05
1995	37.54	0.40	0.09	0.49	$2.97	$0.63	$3.60
1996	38.71	0.40	0.10	0.50	$2.91	$0.73	$3.64
1997	50.00	0.40	0.25	0.65	$2.85	$1.75	$4.59
1998	100	0.40	0.90	1.30	$2.76	$6.15	$8.91
1999	100	0.40	0.90	1.30	$2.70	$6.02	$8.72
2000	100	0.40	0.90	1.30	$2.66	$5.92	$8.58
2001	100	0.40	0.90	1.30	$2.63	$5.85	$8.48
2002	100	0.40	0.90	1.30	$2.60	$5.79	$8.39
2003	100	0.40	0.90	1.30	$2.58	$5.74	$8.32
2004	100	0.40	0.90	1.30	$2.56	$5.70	$8.26
2005	100	0.40	0.90	1.30	$2.54	$5.66	$8.20
2006	100	0.40	0.90	1.30	$2.53	$5.63	$8.15
2007	100	0.40	0.90	1.30	$2.51	$5.60	$8.11
2008	100	0.40	0.90	1.30	$2.50	$5.58	$8.08
2009	100	0.40	0.90	1.30	$2.50	$5.56	$8.06
2010	100	0.40	0.90	1.30	$2.49	$5.54	$8.03
2011	100	0.40	0.90	1.30	$2.48	$5.52	$8.00
2012	100	0.40	0.90	1.30	$2.47	$5.50	$7.98

Table 208-21e							
Average Weight and Cost (2012$) for							
Front Seat Adjustable Anchors							
LTVs							
Model Year	Percent Installed	Weight (lb)			Consumer Cost (2012$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
1989	0	0.00	0.00	0.00	$0.00	$0.00	$0.00
1990	0.1	0.00	0.00	0.00	$0.01	$0.00	$0.01
1991	0.08	0.00	0.00	0.00	$0.01	$0.00	$0.01
1992	0.23	0.00	0.00	0.00	$0.02	$0.00	$0.02
1993	11.48	0.15	0.00	0.15	$1.17	$0.00	$1.17
1994	10.85	0.14	0.00	0.14	$1.07	$0.00	$1.07
1995	12.57	0.14	0.02	0.16	$1.04	$0.16	$1.20
1996	13.62	0.14	0.04	0.18	$1.02	$0.26	$1.28
1997	50.00	0.14	0.51	0.65	$1.00	$3.60	$4.59
1998	100	0.14	1.16	1.30	$0.97	$7.94	$8.91
1999	100	0.14	1.16	1.30	$0.95	$7.77	$8.72
2000	100	0.14	1.16	1.30	$0.93	$7.65	$8.58
2001	100	0.14	1.16	1.30	$0.92	$7.56	$8.48
2002	100	0.14	1.16	1.30	$0.91	$7.48	$8.39
2003	100	0.14	1.16	1.30	$0.90	$7.42	$8.32
2004	100	0.14	1.16	1.30	$0.90	$7.36	$8.26
2005	100	0.14	1.16	1.30	$0.89	$7.31	$8.20
2006	100	0.14	1.16	1.30	$0.88	$7.27	$8.15
2007	100	0.14	1.16	1.30	$0.88	$7.23	$8.11
2008	100	0.14	1.16	1.30	$0.88	$7.20	$8.08
2009	100	0.14	1.16	1.30	$0.87	$7.18	$8.06
2010	100	0.14	1.16	1.30	$0.87	$7.16	$8.03
2011	100	0.14	1.16	1.30	$0.87	$7.14	$8.00
2012	100	0.14	1.16	1.30	$0.87	$7.11	$7.98

Table 208-21f Average Weight and Cost (2012$) for Pretensioners, Load Limiters, and Adjustable Anchors Passenger Cars						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1988	0.00	0.00	0.00	$0.00	$0.00	$0.00
1989	0.01	0.00	0.01	$0.07	$0.00	$0.07
1990	0.01	0.00	0.01	$0.06	$0.00	$0.06
1991	0.02	0.00	0.02	$0.21	$0.00	$0.21
1992	0.18	0.00	0.18	$1.49	$0.00	$1.49
1993	0.29	0.00	0.29	$2.24	$0.00	$2.24
1994	0.40	0.00	0.40	$3.05	$0.00	$3.05
1995	0.40	0.09	0.49	$3.11	$0.63	$3.74
1996	0.41	0.10	0.51	$3.14	$0.73	$3.87
1997	0.42	0.25	0.67	$3.54	$1.75	$5.29
1998	0.50	0.90	1.39	$7.48	$6.15	$13.63
1999	0.82	0.90	1.71	$13.58	$6.02	$19.60
2000	0.95	0.90	1.85	$19.63	$5.92	$25.56
2001	1.09	0.90	1.99	$26.14	$5.85	$31.99
2002	1.19	0.90	2.09	$28.30	$5.79	$34.09
2003	1.22	0.90	2.11	$29.83	$5.74	$35.57
2004	1.28	0.90	2.17	$32.31	$5.70	$38.01
2005	1.31	0.90	2.21	$34.25	$5.66	$39.91
2006	1.39	0.90	2.29	$39.38	$5.63	$45.01
2007	1.39	0.90	2.29	$39.05	$5.60	$44.65
2008	1.39	0.90	2.29	$38.88	$5.58	$44.45
2009	1.39	0.90	2.29	$38.56	$5.56	$44.12
2010	1.39	0.90	2.29	$38.35	$5.54	$43.90
2011	1.39	0.90	2.29	$38.15	$5.52	$43.68
2012	1.39	0.90	2.29	$37.91	$5.50	$43.41

Table 208-21g Average Weight and Cost (2012$) for Pretensioners, Load Limiters, and Adjustable Anchors LTVs						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1988	0.00	0.00	0.00	$0.00	$0.00	$0.00
1989	0.00	0.00	0.00	$0.00	$0.00	$0.00
1990	0.00	0.00	0.00	$0.01	$0.00	$0.01
1991	0.00	0.00	0.00	$0.01	$0.00	$0.01
1992	0.00	0.00	0.00	$0.02	$0.00	$0.02
1993	0.15	0.00	0.15	$1.17	$0.00	$1.17
1994	0.14	0.00	0.14	$1.07	$0.00	$1.07
1995	0.14	0.02	0.16	$1.04	$0.16	$1.21
1996	0.14	0.04	0.18	$1.02	$0.26	$1.28
1997	0.15	0.51	0.66	$1.28	$3.60	$4.88
1998	0.21	1.16	1.37	$3.07	$7.94	$11.01
1999	0.36	1.16	1.52	$6.91	$7.77	$14.69
2000	0.47	1.16	1.63	$9.70	$7.65	$17.35
2001	0.66	1.16	1.82	$18.51	$7.56	$26.06
2002	0.82	1.16	1.98	$24.55	$7.48	$32.03
2003	0.85	1.16	2.01	$25.76	$7.42	$33.18
2004	0.89	1.16	2.05	$27.73	$7.36	$35.09
2005	0.96	1.16	2.12	$31.14	$7.31	$38.45
2006	0.96	1.16	2.12	$31.41	$7.27	$38.68
2007	1.10	1.16	2.26	$35.09	$7.23	$42.32
2008	1.12	1.16	2.28	$36.52	$7.20	$43.73
2009	1.12	1.16	2.28	$36.28	$7.18	$43.46
2010	1.12	1.16	2.28	$36.12	$7.16	$43.28
2011	1.12	1.16	2.28	$36.01	$7.14	$43.15
2012	1.12	1.16	2.28	$35.82	$7.11	$42.93

Passenger Car Studies - Frontal Air Bags

Frontal air bags are designed to save lives and prevent injuries by cushioning occupants as they move forward in a frontal crash. Frontal air bags reduce the likelihood of injury to an occupant's head, neck, face, chest, and abdomen. It is important to note, however, that the air bags are supplemental restraints. The presence of an air bag does not mean it is less important for occupants to use their seat belts. The seat belt, which provides protection in all kinds of crashes, is the primary means of occupant restraint. Frontal air bags provide significant supplemental protection in frontal crashes. Today's frontal air bag requirements have been evolving for more than 40 years. NHTSA issued its first public notice concerning air bags in 1969. Starting in 1972, vehicle manufacturers had the option of installing air bags in passenger cars as a means of complying with FMVSS No. 208. General Motors installed driver and passenger air bags in approximately 10,000 passenger cars in the mid-1970s, but then stopped their production.

We decided to assume our baseline would be linked to the final rule that resulted in air bag production restarting. That was the final rule, published in the Federal Register on July 17, 1984, (49 FR 28962), that required automatic restraint systems for the front outboard seats in passenger cars in response to the persistent low usage rate of manual belts. The requirement was phased in starting September 1, 1986 with full implementation by September 1, 1989. The front center seat of passenger cars was exempt from, and rear seats were not covered by, the requirements. The NPRM was published in the Federal Register on October 14, 1983, (48 FR 48622) making the baseline date September 1, 1983, or MY 1984. There were no driver side air bags or passenger side air bags in MY 1984 passenger cars or LTVs, thus we assume that the baseline is 0 percent and all air bags are attributed to FMVSS No. 208.

To encourage the development and introduction of non-belt automatic restraint systems, the requirement also provided that manufacturers that installed a non-belt system, such as an air bag, at the driver's seating position could install a manual lap/shoulder belt rather than an automatic system at the front right seating position. A further amendment in March 1987 extended this option until September 1, 1993, to expedite the introduction of driver air bags while allowing adequate lead-time for introduction of right front passenger bags.

In 1991 Congress directed NHTSA to issue a final rule requiring that automatic crash protection must be provided by an inflatable restraint (i.e., an air bag) in passenger cars, LTVs, multipurpose vehicles, and buses with a GVWR of 8,500 pounds or less. In addition, the seating positions protected by an air bag must also be equipped with a manual lap/shoulder belt. The final rule was published in the Federal Register on September 2, 1993[152] requiring at least 95 percent of each manufacturer's passenger cars manufactured on or after September 1, 1996, and before September 1, 1997, must be equipped with an air bag and a manual lap/shoulder belt at both the driver's and right front passenger's seating position. Every passenger car manufactured on or after September 1, 1997, must be so equipped. The vehicle manufacturers, however, were ahead of the implementation schedule. Nearly every 1996 model year passenger car was equipped with both driver- and passenger-side air bags as standard equipment.

Like the automatic restraint requirements issued in 1984, the air bag requirements were performance requirements that did not specify the design of an air bag system. Instead, vehicles had to meet specified injury criteria, including criteria for the head and chest, measured on test dummies during a barrier crash test at speeds up to 30 mph. These criteria had to be met for air bag equipped vehicles both when the dummies were belted and when they were unbelted. These requirements applied to the performance of the vehicle as a whole, and not to the air bags as a separate item of motor vehicle equipment. This permitted vehicle manufacturers to tune the

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[152] *Federal Register*, Vol. 58, No. 169, pg. 46551.

performance of the air bag to the crash pulse and other specific attributes of each of their vehicles and left them free to select specific attributes for their air bags, such as dimensions, actuation time, etc.

A series of cost and weight analyses were performed on air bags from twelve passenger cars[153] [154] [155] [156] of various model years. Table 208-22 shows the arithmetic average weight and consumer cost, for three model year groups, for driver air bags and dual air bags and the model year vehicles that were analyzed. The passenger bag weights and costs below are simply the subtraction of the driver side air bag from the dual air bag results.

Redesigned Frontal Air Bags

Frontal air bags have constantly evolved over time. The previous section discussed just the basic frontal air bags. In October 1995, NHTSA began a series of actions to reduce and eventually eliminate the adverse effect of air bags for infants, children and other high-risk occupants while retaining, to the largest extent possible, the great life-saving benefits of air bags for most people. Specifically, on March 19, 1997, NHTSA amended FMVSS No. 208, effective immediately (i.e., in time to allow implementation in MY 1998 or, at the latest MY 1999), relaxing some aspects of the frontal impact test for the unrestrained dummy in order to facilitate the introduction of redesigned air bags that deploy less forcefully. Instead of a barrier-crash test with an actual vehicle, manufacturers could temporarily use a sled test with a deceleration pulse stipulated in FMVSS No. 208, resembling the deceleration of a typical large passenger car in a barrier impact – i.e., relatively gradual.[157]

In approximately 84 percent of driver air bags and 70 percent of passenger bags, suppliers achieved less forceful deployments by literally depowering the air bags: removing some of the gas-generating propellant. Others replaced or supplemented the propellant with a cylinder of stored argon gas. NHTSA has no cost teardown studies for redesigned frontal air bags of MYs 1998 to 2006.

Advanced Frontal Air Bags

In 1998, Congress directed NHTSA to issue a final rule mandating the use of advanced air bags to improve occupant protection for occupants of different sizes, belted and unbelted, while minimizing the risk to infants, children, and other occupants from injuries and deaths caused by air bags. On May 12, 2000, NHTSA added a section S14 to FMVSS No. 208 to phase in advanced frontal air bags from September 1, 2003, to September 1, 2006. The options for

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[153] Khadilkar, Fladmark, & Firth, DOT HS 807 321 and DOT HS 807 322, 1988, Docket No. 2011-0066-0037 and 0038. Only driver air bags were specifically cost estimated for a MY 1987 Ford Tempo and MY 1987 Mercedes 190.

[154] Fladmark & Khadilkar, DOT HS 807 949, 807 950, & 807 951, 1992, Docket No. 2011-0066-0031, 0032, and 0036.

[155] Fladmark & Khadilkar, DOT HS 809 798, 1996, Docket No. 2011-0066-0024.

[156] Fladmark & Khadilkar, DOT HS 809 801-802, 1997, Docket No. 2011-0066-0020 and 0021.

[157] *Federal Register* 62 (March 19, 1997): 12960; *Code of Federal Regulations,* Title 49, Part 571.208 S13.

advanced air bags are: that they do not deploy at all for children (suppression), deploy only at a low level of force (low-risk deployment), or track an occupant's motion and suppress the air bag if they are too close (dynamic automatic suppression). However, no vehicles have ever employed dynamic automatic suppression. The predominant option is suppression, based on a weight sensor in the right front seat that automatically switches off the air bag unless it detects a mass greater than a predetermined threshold. Some manufacturers use weight sensors with two thresholds: suppression upon sensing low mass, low-risk deployment for an intermediate range of mass (e.g., a range that includes the average weight of a 6-year-old child), and normal deployment above that range.

During this timeframe, NHTSA also modified and in some cases strengthened selected performance requirements in FMVSS No. 208. NHTSA reinstated a barrier crash test with an unbelted 50th percentile adult male ATD (dummy), in place of the sled test; however, the maximum speed for that test is now in a range of 20 to 25 mph (as compared to the range of 0 to 30 mph in the original barrier test and the sled test with a 28-to-30 mph velocity change). NHTSA may conduct the test with a barrier that is perpendicular to the vehicle's line of travel or tilted at any angle up to 30 degrees in either direction to simulate an oblique crash. Also, during this timeframe, the standard required testing the performance for small-stature adults represented by a belted 5th percentile female Hybrid III ATD in a 30 mph perpendicular-barrier test. The test with the belted 50th percentile male ATD was upgraded from 30 mph to 35 mph, phasing in from September 1, 2007, to September 1, 2010. On August 31, 2006, NHTSA amended FMVSS No. 208 to likewise upgrade the test with the belted 5th percentile female from 30 mph to 35 mph, phasing in from September 1, 2009, to September 1, 2012. During the 2000s, in addition to designing to the amended regulations, manufacturers also introduced features to tailor deployments to the needs of the occupant. The features include multi-stage inflators to allow various alternative force levels for deployments, seat-belt use sensors that can influence whether or how forcefully the air bag should deploy, and seat-track sensors that can detect if an occupant is sitting close to the air bag.[158] These same features were used to meet the variety of changes required by amendments in air bag testing requirements.

A cost teardown report[159] on MY 2007 vehicles estimated the total cost of dual air bags at that time including all of the advanced air bags technologies. One of the four MY 2007 vehicles used in the passenger car analysis was a LTV. The SUV air bag estimates were very similar to the weights and costs of the 3 passenger cars and all were combined into one average. As Table 208-22 shows, even with advanced technologies being added to the weight and cost of air bags the overall weight and cost went down substantially compared to MY 1996. Some of this cost reduction, which we cannot quantify, might be due to the relaxation of the unbelted test requirements. We assume the same weights and costs for advanced air bags for LTVs as for passenger cars.

[158] 49 CFR, Part 572.208 S14; *Federal Register* 65 (May 12, 2000): 30679, 71 (August 31, 2006): 57168; Greenwell, N. K. (2013, July). *Evaluation of the certified-advanced air bags* (Report No. DOT HS 811 834). Washington, DC: National Highway Traffic Safety Administration. Available at www-nrd.nhtsa.dot.gov/Pubs/811834.pdf.
[159] Ludtke & Associates, Docket No. 2011-0066-0001, 2008.

TABLE 208-22 AVERAGE WEIGHT AND CONSUMER COST OF AIR BAGS IN PASSENGER CARS DATA FROM TEARDOWN ANALYSES		
MODEL YEAR	**WEIGHT IN POUNDS**	**CONSUMER COST ($2012)**
Driver Air Bags		
1987	25.93	$511.55
1992-1996	13.46	$350.71
2007	4.00	$174.75
Passenger Air Bags		
1992-1996	13.30	$139.04
2007	8.80	$171.13
Dual Air Bags		
1992-1996	26.76	$489.75
2007	12.80	$345.88

The high estimate of driver air bags in 1987 probably reflects the inefficiencies of initial implementation. In its cost teardowns NHTSA assumes many of the components of the basic system are charged to the driver air bag (for example the crash sensors, the electronic control unit, wiring to everything but the passenger bag, etc.). Thus, historically the driver air bag costs are higher than the passenger air bag costs (see Table 208-22 for 1992-1996 models where the driver side is credited with 2.5 times the cost of the passenger side - $350.71 versus $139.04). This changes dramatically by the next cost teardown of MY 2007 (and is assumed to change by 2004 with the phase-in) with the addition of advanced technologies which focus mainly on the passenger side. The passenger air bag itself is larger and covers more area than the driver air bag and is more expensive. The weight sensor and electronic control unit for it add cost to the point that the passenger air bag is about the same price as the driver side, even though the driver side is still charged with the crash sensors and basic electronic control unit. See Table 208-23a and 208-23b for the comparisons.

The main components of a MY 1992 to MY 1996 air bag system are the:

- Air Bag Module. The air bag module contains both an inflator unit and the lightweight fabric air bag. The driver air bag module is located in the steering wheel hub, and the passenger air bag module is located in the instrument panel.

- Igniter/Inflator. The igniter assemblies are electrical devices that ignite a chemical gas generator that uses a sodium azide/sodium nitrate generant. Upon ignition, the generant produces nitrogen gas that fills the bag assemblies, creating a cushion effect. Some vehicles use a cylinder of compressed argon gas rather than/in addition to an ignitable propellant.

- Control Module/Sensors. The control module is usually installed in the longitudinal center of the car between the passenger and engine compartment. The sensors continuously monitor the acceleration and deceleration of the vehicle and send this information to a microprocessor where the crash pulse of a vehicle is stored. When the microprocessor recognizes the crash pulse from the sensor, an electrical current is sent to the inflator of the air bag that should be deployed.

- Clock Spring. The clock spring, or SIR coil, is located in the steering column and has several wraps of wire that look much like the spring in a clock. This assembly allows for one end to be connected to the wiring harness for the air bag system and the other end to be connected to the air bag in the steering wheel. The wraps of wire wind in and out as the steering wheel is turned, which allows the steering wheel to move while maintaining the electrical connection to the air bag module.

- Wiring Harness. The wiring harness is a collection of wires that is designed to control electrical functions in one section of a vehicle. Most wiring harnesses feature simple plug-in connectors, so components can be changed without the need to splice wires.

- Knee Bolster. The knee bolster is a padded bar on the lower part of the dashboard that is used in conjunction with frontal air bags to reduce lower limb injury and the risk of gliding under the seat belt during a crash.

Table 208-23a shows the arithmetic average weight and consumer cost of the principal components of dual air bags for MY 1992 to MY 1996. Table 208-23b shows similar information for MY 2007. Here we have combined and averaged four different vehicles, and given things similar names, although each manufacturer may handle the weight sensing and electronic control function for suppression and low risk air bags on the passenger side differently.

TABLE 208-23a
AVERAGE WEIGHT AND CONSUMER COST OF PRINCIPAL COMPONENTS IN DUAL AIR BAGS IN PASSENGER CARS FROM 1992-1996

PRINCIPAL COMPONENTS	WEIGHT IN POUNDS	CONSUMER COST ($2012)
Driver Air Bag and Inflator Assembly	3.60	$ 80.28
Passenger Air Bag and Inflator Assembly	11.58	$158.19
Knee Bolster	7.37	$ 36.48
Control Module and Sensors	2.87	$165.27
Clock Spring Assembly	0.41	$ 16.69
Wiring Harness	0.93	$ 32.84
TOTAL	26.76	$489.75

Table 208-23b					
Average Weight and Consumer Cost (2012$)					
Principal Components in Dual Air Bag System					
Passenger Cars MY 2007					
		Weight	**Weight**	**Consumer Cost**	
		Driver	**Passenger**	**Driver**	**Pass**
	Air bag	2.97	7.15	$78.40	$117.88
	ECU	0.80	1.23	$82.16	$27.99
Crash	sensor	0.19	0.00	$12.20	$0.00
Seat	sensor	0.02	0.11	$0.85	$9.76
Strain/occupant	sensor	0.00	0.20	$0.00	$12.51
Dash	light	0.01	0.00	$0.32	$0.64
Belt use	sensor	0.03	0.11	$0.82	$2.35
	Total	4.00	8.80	$174.75	$171.13

Table 208-23c and Table 208-23d provide the results of all the calculations for passenger car air bags by model year for the driver position and passenger position respectively. Provided are the average weight and cost, taking into account the percentage of the fleet that were equipped with air bags.

For weight, 25.93 pounds was assumed for driver air bags from 1985 to 1989, 13.46 pounds was assumed for driver air bags from 1992 to 1996, and 4.0 pounds was assumed for 2007 to 2012. In between these years we assume a linear decline in weight from 1989 to 1992 and then from 1996 to 2007. The difference between the dual air bags and driver side air bags of 13.3 pounds found in 1992 to 1996 models was assumed for the passenger side through 1996. For the passenger side air bag, for 2004 to 2012, 8.8 pounds was assumed and in between those years a linear decline is assumed starting at 13.3 pounds in 1996 and reaching the weight of the 2007 passenger side air bag without counting the advanced air bag features of 7.15 pounds in 2003.

For cost, $511.55 was assumed for driver air bags from 1985 to 1989 (in Table 208-23c the driver cost in MY 1985 is $511.55 * 0.11 percent (percent installed for MY 1985 from Table 23c) or 0.0011 = $0.56), $350.71 was assumed for driver air bags from 1992 to 1996, and $174.75 was assumed for 2007 to 2012. In between these years we assume a linear decline in cost from 1989 to 1992 and then from 1996 to 2007. The difference between the dual air bags and driver side air bags of $139.04 found in 1992 to 1996 models was assumed for the passenger side through 1996. For the passenger side air bag, for 2004 to 2012, $171.13 was assumed and in between those years (1997 to 2003) a linear decline is assumed starting at $139.04 in 1996 and reaching the cost of the MY 2007 passenger side air bag alone without counting the advanced air bag features of $117.88 in 2003. We use these linear declines because air bags were constantly evolving and suppliers were under constant pressure from the manufacturers to make them less expensive and we do not have cost estimates for every model year. We used the data from the teardown studies where available, and then the learning curve was applied from MY 2007 to MY 2012 for the driver side and from MY 2004 to MY 2012 for the passenger side.

Table 208-23d
Weight (lb) and Consumer Cost (2012$)
Right Front Passenger Air Bags - Passenger Cars

Model Year	Percent Install	Weight (lb)			Consumer Cost (2012$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
1984	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0
1987	0.05	0	0.01	0.01	0	$0.07	$0.07
1988	0.03	0	0.00	0.00	0	$0.04	$0.04
1989	0.39	0	0.05	0.05	0	$0.54	$0.54
1990	1.4	0	0.19	0.19	0	$1.95	$1.95
1991	0.59	0	0.08	0.08	0	$0.82	$0.82
1992	4.45	0	0.59	0.59	0	$6.19	$6.19
1993	12.3	0	1.64	1.64	0	$17.10	$17.10
1994	54.88	0	7.30	7.30	0	$76.31	$76.31
1995	88.77	0	11.81	11.81	0	$123.43	$123.43
1996	93.24	0	12.40	12.40	0	$129.64	$129.64
1997	100	0	12.42	12.42	0	$136.02	$136.02
1998	100	0	11.54	11.54	0	$132.99	$132.99
1999	100	0	10.66	10.66	0	$129.97	$129.97
2000	100	0	9.79	9.79	0	$126.95	$126.95
2001	100	0	8.91	8.91	0	$123.92	$123.92
2002	100	0	8.03	8.03	0	$120.90	$120.90
2003	100	0	7.15	7.15	0	$117.88	$117.88
2004	100	0	8.80	8.80	0	$176.13	$176.13
2005	100	0	8.80	8.80	0	$174.24	$174.24
2006	100	0	8.80	8.80	0	$172.59	$172.59
2007	100	0	8.80	8.80	0	$171.13	$171.13
2008	100	0	8.80	8.80	0	$170.02	$170.02
2009	100	0	8.80	8.80	0	$169.20	$169.20
2010	100	0	8.80	8.80	0	$168.33	$168.33
2011	100	0	8.80	8.80	0	$167.43	$167.43
2012	100	0	8.80	8.80	0	$166.46	$166.46

LTVs Studies - Frontal Air Bags

Although FMVSS No. 208 has long required the installation of seat belts at all designated seating positions in LTVs, it did not originally require those vehicles to provide automatic crash protection at the same time as passenger cars. On March 26, 1991, (56 FR 12472), a final rule was published in the Federal Register amending FMVSS No. 208 to extend automatic protection to front outboard seats to most but not all LTVs, by extending the requirements to trucks and multipurpose passenger vehicles with a GVWR of 8,500 pounds or less. The rule provided that the automatic restraint requirement would be phased into most LTVs over a three-year period starting on September 1, 1994. The two types of automatic crash protection available to manufacturers for installation in their vehicles were air bags and automatic belts. However, in September 1993, NHTSA amended FMVSS No. 208 to require that all passenger cars and applicable LTVs provide automatic protection by means of air bags. Every LTV (with a GVWR of 8,500 pounds or less) manufactured on or after September 1, 1998, would have to be equipped with an air bag and a manual lap/shoulder belt at both the driver's and right front passenger's seating positions. The vehicle manufacturers were far ahead of the implementation schedule, and a large number of MY 1996 LTVs were equipped with air bags. The NPRM was published in the Federal Register on January 9, 1990, (55 FR 747) making the baseline date September 1, 1989, or MY 1990. In MY 1990, no LTVs had frontal air bags. Thus, all air bag installations are considered attributable to FMVSS No. 208.

A series of cost and weight analyses were performed on air bags from six MY 1995-96 LTVs.[160] [161] These weight and cost estimates are very close to the MY 1992-96 passenger cars shown in Table 208-23a. One of the four MY 2007 vehicles used in the passenger car analysis was a LTV. The SUV air bag estimates were very similar to the weights and costs of the 3 passenger cars and all were combined into one average. Table 208-24a shows the arithmetic average weight and consumer cost for driver air bags and dual air bags.

TABLE 208-24a
AVERAGE WEIGHT AND CONSUMER COST
OF AIR BAGS IN LTVS

MODEL YEAR	WEIGHT IN POUNDS	CONSUMER COST ($2012)
Driver Air Bags		
1996	14.31	$328.11
2007	4.00	$174.75
Passenger Air Bags		
1995-1996	12.17	$145.63
2007	8.80	$171.13
Dual Air Bags		
1995-1996	26.48	$473.74
2007	12.80	$345.88

The main components of an air bag system are the air bag module, igniter/inflator, control module/sensors, clock spring, wiring harness, and knee bolster. Table 208-24b shows the average

[160] Fladmark & Khadilkar, DOT HS 809 799, 1996, Docket No. 2011-0066-0023.
[161] Fladmark and Khadilkar, DOT HS 809 801& and DOT HS 809 802,1997, Docket No. 2011-0066-0020 and 0021.

costs of the principal components of dual air bags for 1995-1996. The total cost and weight of air bags and the cost of the main components are about the same as in passenger cars. Table 208-23b shows the breakdown of principal components for dual air bags for 2007. Since we assume that passenger car and LTV air bags have essentially the same weight and cost impacts by this time, it isn’t necessary to repeat the same table.

TABLE 208-24b
AVERAGE WEIGHT AND CONSUMER COST
OF PRINCIPAL COMPONENTS IN DUAL AIR BAGS
IN LTVS FROM 1995-1996

PRINCIPAL COMPONENTS	WEIGHT IN POUNDS	CONSUMER COST ($2012)
Driver Air Bag and Inflator Assembly	3.50	$ 70.50
Passenger Air Bag and Inflator Assembly	10.39	$130.13
Knee Bolster	7.82	$ 38.71
Control Module and Sensors	3.00	$169.64
Clock Spring Assembly	0.43	$ 16.81
Wiring Harness	1.34	$ 47.94
TOTAL	26.48	$473.74

Table 208-24c and Table 208-24d provide the results of all the calculations for LTV air bags by model year. Provided are the average weight and cost, taking into account the percentage of the fleet that were equipped with air bags.

For weight, 14.31 pounds was assumed for driver air bags from 1992 to 1996, and 4.0 pounds was assumed for 2007 to 2012. In between these years we assume a linear decline in weight from 1996 to 2007. For the passenger side air bag, we assume 12.17 pounds for 1994 to 1996 and for 2004 to 2012, 8.8 pounds was assumed and in between those years a linear decline is assumed starting at 12.17 pounds in 1996 and reaching the weight of the 2007 passenger side air bag without counting the advanced air bag features of 7.15 pounds in 2003.

For cost, LTV driver air bags cost $350.71 from 1992 to 1996 (in Table 208-24c the driver cost in MY 1992 is $350.71 * 13.05 percent or 0.1305 = $45.77), and $174.75 was assumed for 2007 to 2012. In between these years we assume a linear decline in cost. The difference between the dual air bags and driver side air bags of $145.63 found in 1995 to 1996 models was assumed for the passenger side through 1996. For the passenger side air bag, for 2004 to 2012, $171.13 was assumed and in between those years (1997 to 2003) a linear decline is assumed starting at $145.63 in 1996 and reaching the cost of the MY 2007 passenger side air bag without counting the advanced air bag features of $117.88 in 2003. We used the data from the teardown studies where available, and then the learning curve was applied starting in MY 2007 for the driver side and MY 2004 for the passenger side.

Table 208-24c							
Weight (lb) and Consumer Cost (2012$)							
Driver Air Bags - LTVs							
Model Year	Percent Install	Weight (lb)			Consumer Cost (2012$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
1991	0	0	0	0	0	0	0
1992	13.05	0	1.87	1.87	0	$45.77	$45.77
1993	19.31	0	2.76	2.76	0	$67.72	$67.72
1994	32.32	0	4.62	4.62	0	$113.35	$113.35
1995	82.5	0	11.81	11.81	0	$289.34	$289.34
1996	96.99	0	13.88	13.88	0	$340.15	$340.15
1997	96.97	0	12.63	12.63	0	$324.57	$324.57
1998	99.74	0	11.70	11.70	0	$317.89	$317.89
1999	99.88	0	10.43	10.43	0	$302.36	$302.36
2000	100	0	9.16	9.16	0	$286.73	$286.73
2001	100	0	7.87	7.87	0	$270.73	$270.73
2002	100	0	6.58	6.58	0	$254.73	$254.73
2003	100	0	5.29	5.29	0	$238.74	$238.74
2004	100	0	4.00	4.00	0	$222.74	$222.74
2005	100	0	4.00	4.00	0	$206.75	$206.75
2006	100	0	4.00	4.00	0	$190.75	$190.75
2007	100	0	4.00	4.00	0	$174.75	$174.75
2008	100	0	4.00	4.00	0	$173.76	$173.76
2009	100	0	4.00	4.00	0	$173.02	$173.02
2010	100	0	4.00	4.00	0	$172.23	$172.23
2011	100	0	4.00	4.00	0	$171.41	$171.41
2012	100	0	4.00	4.00	0	$170.52	$170.52

Table 208-24d							
Weight (lb) and Consumer Cost (2012$)							
Right Front Passenger Air Bags - LTVs							
Model Year	**Percent Install**	**Weight (lb)**			**Consumer Cost (2012$)**		
		Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1991	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0
1994	7.86	0	1.0	1.0	0	$10.93	$10.93
1995	14.97	0	1.8	1.8	0	$20.81	$20.81
1996	41.46	0	5.0	5.0	0	$57.65	$57.65
1997	71.59	0	8.2	8.2	0	$97.38	$97.38
1998	99.64	0	10.7	10.7	0	$132.52	$132.52
1999	99.88	0	10.0	10.0	0	$129.82	$129.82
2000	100	0	9.3	9.3	0	$126.95	$126.95
2001	100	0	8.6	8.6	0	$123.92	$123.92
2002	100	0	7.9	7.9	0	$120.90	$120.90
2003	100	0	7.2	7.2	0	$117.88	$117.88
2004	100	0	8.8	8.8	0	$176.13	$176.13
2005	100	0	8.8	8.8	0	$174.24	$174.24
2006	100	0	8.8	8.8	0	$172.59	$172.59
2007	100	0	8.8	8.8	0	$171.13	$171.13
2008	100	0	8.8	8.8	0	$170.02	$170.02
2009	100	0	8.8	8.8	0	$169.20	$169.20
2010	100	0	8.8	8.8	0	$168.33	$168.33
2011	100	0	8.8	8.8	0	$167.43	$167.43
2012	100	0	8.8	8.8	0	$166.46	$166.46

Manual On-Off Switches

While air bags were providing significant overall safety benefits, NHTSA was very concerned that current designs had adverse effects, especially on children in rear-facing child seats installed in front passenger positions. To address this dilemma, NHTSA published a final rule on May 23, 1995, (60 FR 27233) amending FMVSS No. 208 to allow manual on-off switches for passenger-side air bags in pickup trucks and other vehicles with small or no rear seats. The NPRM was published in the Federal Register on October 7, 1994, (59 FR 51158), making the baseline date September 1, 1994, or MY 1995. Regardless of the baseline date, a manual on-off switch was not required by the standard but was an option provided to manufacturers. Thus, it is considered voluntary and not attributable to the standard. The final rule allowed manufacturers the option of installing a manual device that motorists could use to deactivate the front passenger-side air bag in vehicles manufactured on or after June 22, 1995, that cannot accommodate rear-facing child seats anywhere except in the front seat. The manual on-off switch had to use an ignition key to turn off the passenger air bag and to turn on the air bag. In addition, the manufacturer had to install a warning light that was separate from the air bag readiness indicator, which would indicate when the air bag was turned off. The light had to be visible to both the driver and the passenger. Less than 1 percent of passenger cars came equipped with an on-off switch for vehicles with no rear seat or with a rear seat that was so small that it couldn't accommodate a child restraint. By MY 1998, switches for the passenger bag had become standard equipment in all pickup trucks with a GVWR of 8,500 pounds or less that could not accommodate a rear-facing infant seat in the rear seat. That basically includes all conventional cabs (no rear seats) and extended cabs (small rear seats) and only excludes certain full crew cabs. An air bag on-off switch was also provided in some SUVs, like the Jeep Wrangler and in some full size cargo vans that didn't have a rear seat. In MY 1998, almost 42 percent of all LTVs had on-off switches. The 2000 advanced air bag rule included a sunset provision on these original equipment air bag on-off switches, sunsetting them on September 1, 2012. By MY 2012, there were no more manual on-off switches installed by manufacturers for the front right passenger air bag.

A cost and weight analysis was performed on air bag on-off switch systems.[162] The sample consisted of one passenger car and one minivan of MY 1998 for which the original equipment manufacturer had supplied aftermarket on-off switches for both the driver and for the right front passenger. Because these switches were nearly identical, we have assumed that the cost of a factory-installed switch for the right front passenger would be half of the cost per vehicle found in the teardown study. Table 208-25a shows the arithmetic average weight and consumer cost of one on-off switch.

TABLE 208-25a
AVERAGE WEIGHT AND CONSUMER COST PER SWITCH OF PASSENGER SIDE ON-OFF SWITCHES

COMPONENT	WEIGHT IN POUNDS	CONSUMER COST ($2012)
On-off Switches	0.65	$34.71

Table 208-25b and Table 208-25c show the percentage of the fleet equipped with manual on-off switches and the average weight and consumer cost after applying the learning curve for passenger cars and LTVs.

[162] Fladmark, G. L., & Khadilkar, A. V. (1998, December). *Cost estimates of one (1) side impact crash protection for 1998 model year passenger car and two (2) automatic crash protection on-off switches for 1998 model year passenger car* (Report No. DOT HS 809 805) Washington, DC: National Highway Traffic Safety Administration, Docket No. 2011-0066-0017.

Table 208-25b Average Weight and Cost (2012$) for Manual On-off Switches Passenger Cars							
Model Year	**% Installed**	**Weight (lb)**			**Consumer Cost (2012$)**		
		Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1996	0	0.00	0	0.00	$0.00	0	$0.00
1997	0	0.00	0	0.00	$0.00	0	$0.00
1998	0.01	0.00	0	0.00	$0.00	0	$0.00
1999	0.30	0.00	0	0.00	$0.10	0	$0.10
2000	0.22	0.00	0	0.00	$0.07	0	$0.07
2001	0.71	0.00	0	0.00	$0.22	0	$0.22
2002	0.68	0.00	0	0.00	$0.21	0	$0.21
2003	0.69	0.00	0	0.00	$0.21	0	$0.21
2004	0.58	0.00	0	0.00	$0.17	0	$0.17
2005	0.51	0.00	0	0.00	$0.15	0	$0.15
2006	0.22	0.00	0	0.00	$0.06	0	$0.06
2007	0.07	0.00	0	0.00	$0.02	0	$0.02
2008	0.17	0.00	0	0.00	$0.05	0	$0.05
2009	0.09	0.00	0	0.00	$0.03	0	$0.03
2010	0	0.00	0	0.00	$0.00	0	$0.00
2011	0	0.00	0	0.00	$0.00	0	$0.00
2012	0	0.00	0	0.00	$0.00	0	$0.00

Table 208-25c							
Average Weight and Cost (2012$) for							
Manual On-off Switches							
LTVs							
Model Year	**% Installed**	**Weight (lb)**			**Consumer Cost (2012$)**		
		Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1996	0	0	0	0	$0.00	0	$0.00
1997	21.44	0.14	0	0.14	$8.38	0	$8.38
1998	41.87	0.27	0	0.27	$14.53	0	$14.53
1999	41.97	0.27	0	0.27	$13.73	0	$13.73
2000	41.16	0.27	0	0.27	$12.97	0	$12.97
2001	38.97	0.25	0	0.25	$11.94	0	$11.94
2002	28.65	0.19	0	0.19	$8.64	0	$8.64
2003	17.89	0.12	0	0.12	$5.34	0	$5.34
2004	15.73	0.10	0	0.10	$4.66	0	$4.66
2005	6.03	0.04	0	0.04	$1.78	0	$1.78
2006	4.61	0.03	0	0.03	$1.36	0	$1.36
2007	2.00	0.01	0	0.01	$0.59	0	$0.59
2008	1.50	0.01	0	0.01	$0.44	0	$0.44
2009	0.66	0.00	0	0.00	$0.19	0	$0.19
2010	0.66	0.00	0	0.00	$0.19	0	$0.19
2011	0.68	0.00	0	0.00	$0.20	0	$0.20
2012	0	0.00	0	0.00	$0.00	0	$0.00

Summary Tables for FMVSS No. 208/209/210

Table 208-26a for passenger cars and Table 208-26b for LTVs summarize the total consumer weight and cost of the occupant protection systems installed in these vehicles for MYs 1968-2012. These totals include all of the manual belts, automatic belts, pretensioners, load limiters, and adjustable anchors, air bags and manual on-off switches. The summary calculations are the average weight and cost per vehicle taking into account installation rates.

Table 208-26a						
Summary Table for FMVSS No. 208/209/2010						
Passenger Cars						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1968	0.01	10.43	10.44	$0.02	$113.96	$113.98
1969	0.01	10.57	10.58	$0.03	$114.16	$114.18
1970	0.01	10.57	10.58	$0.03	$113.95	$113.98
1971	0.01	10.57	10.58	$0.03	$113.76	$113.79
1972	2.81	12.45	15.26	$23.58	$121.61	$145.18
1973	3.21	12.45	15.66	$26.96	$121.03	$147.98
1974	3.33	12.33	15.66	$34.64	$120.62	$155.27
1975	3.38	12.80	16.19	$34.97	$120.36	$155.33
1976	3.38	13.27	16.64	$34.88	$119.98	$154.86
1977	3.39	13.56	16.95	$34.90	$116.78	$151.68
1978	3.39	14.02	17.41	$34.90	$116.44	$151.35
1979	3.40	14.49	17.89	$34.96	$115.93	$150.89
1980	3.41	14.49	17.90	$35.02	$115.73	$150.75
1981	3.51	14.48	17.99	$36.81	$115.64	$152.45
1982	3.46	13.97	17.43	$36.35	$113.67	$150.02
1983	3.47	13.46	16.93	$37.19	$111.74	$148.93
1984	3.40	12.95	16.35	$36.04	$109.71	$145.76
1985	3.32	12.54	15.86	$34.81	$109.35	$144.16
1986	3.32	12.15	15.46	$34.83	$109.68	$144.51
1987	3.11	13.55	16.66	$32.83	$135.11	$167.94
1988	2.56	14.90	17.46	$31.55	$155.45	$187.01
1989	2.46	16.17	18.63	$30.46	$179.34	$209.80
1990	2.87	25.56	28.43	$22.36	$361.22	$383.58
1991	2.86	25.22	28.07	$22.14	$373.62	$395.76
1992	3.38	24.01	27.39	$27.69	$381.42	$409.11
1993	3.53	26.81	30.34	$28.97	$435.31	$464.28
1994	3.86	33.05	36.91	$32.18	$534.36	$566.54
1995	4.25	37.07	41.32	$36.48	$596.80	$633.28
1996	4.38	36.80	41.17	$37.88	$590.29	$628.17
1997	4.64	35.42	40.06	$40.76	$571.17	$611.92
1998	4.98	34.33	39.31	$46.76	$556.14	$602.90
1999	5.37	32.59	37.96	$53.23	$536.58	$589.81
2000	5.72	30.85	36.57	$60.62	$517.08	$577.70
2001	6.15	29.11	35.27	$69.11	$497.64	$566.75
2002	6.34	27.37	33.72	$71.52	$478.25	$549.77

2003	6.69	25.57	32.26	$74.92	$457.49	$532.42
2004	6.77	26.47	33.24	$77.68	$499.57	$577.25
2005	6.80	25.72	32.51	$79.82	$481.41	$561.23
2006	6.86	24.95	31.81	$85.00	$463.51	$548.51
2007	6.86	24.09	30.95	$84.32	$445.81	$530.12
2008	6.92	24.05	30.97	$84.07	$442.52	$526.59
2009	6.91	24.05	30.96	$83.56	$440.82	$524.38
2010	6.91	24.05	30.96	$83.16	$439.01	$522.17
2011	6.91	24.05	30.96	$82.78	$437.12	$519.91
2012	6.91	24.05	30.96	$82.36	$435.10	$517.45

Table 208-26b
Summary Table for FMVSS No. 208/209/2010
LTVs

Model Year	Weight (lb)			Consumer Cost (2012$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0.00	5.81	5.81	$0.00	$70.54	$70.54
1969	0.02	5.81	5.83	$0.09	$70.36	$70.45
1970	0.02	5.81	5.83	$0.11	$70.23	$70.34
1971	0.02	5.81	5.83	$0.13	$70.11	$70.24
1972	0.03	10.66	10.70	$1.92	$102.11	$104.03
1973	0.27	10.42	10.70	$3.55	$100.04	$103.58
1974	2.05	8.85	10.90	$26.35	$80.63	$106.98
1975	2.20	8.71	10.91	$28.12	$78.72	$106.83
1976	2.26	8.65	10.91	$28.67	$77.78	$106.45
1977	4.27	8.19	12.45	$53.60	$67.69	$121.30
1978	4.30	8.15	12.45	$53.66	$66.92	$120.59
1979	4.25	8.18	12.44	$52.69	$67.19	$119.88
1980	4.77	7.73	12.50	$58.82	$61.29	$120.12
1981	5.06	7.47	12.53	$62.13	$57.91	$120.04
1982	5.06	7.47	12.53	$61.89	$57.72	$119.61
1983	5.06	7.48	12.54	$61.64	$57.51	$119.15
1984	5.06	7.48	12.54	$61.36	$57.28	$118.63
1985	5.06	7.49	12.55	$61.07	$57.04	$118.12
1986	5.06	7.49	12.55	$60.80	$56.82	$117.62
1987	5.06	9.02	14.08	$60.58	$70.53	$131.12
1988	5.06	9.02	14.08	$60.43	$70.32	$130.76
1989	5.06	8.99	14.05	$60.36	$70.16	$130.53
1990	5.08	8.97	14.05	$60.38	$69.77	$130.15
1991	5.15	8.87	14.02	$60.84	$68.93	$129.78

1992	5.54	10.18	15.71	$63.97	$110.57	$174.54
1993	5.68	11.08	16.76	$64.91	$132.08	$196.99
1994	5.67	13.89	19.57	$64.59	$188.24	$252.83
1995	6.06	24.36	30.42	$67.56	$395.65	$463.21
1996	6.06	29.67	35.74	$67.31	$482.94	$550.25
1997	6.22	32.05	38.26	$75.75	$510.02	$585.77
1998	6.41	34.27	40.67	$83.52	$542.45	$625.97
1999	6.57	32.31	38.88	$86.46	$523.69	$610.15
2000	6.69	30.33	37.02	$88.39	$504.73	$593.12
2001	6.95	28.32	35.27	$96.63	$485.31	$581.94
2002	7.26	26.31	33.57	$100.74	$465.94	$566.68
2003	7.88	24.49	32.37	$103.02	$446.27	$549.29
2004	8.05	24.99	33.03	$103.90	$490.12	$594.02
2005	8.08	25.15	33.22	$104.08	$473.08	$577.16
2006	8.03	25.37	33.40	$103.62	$456.28	$559.91
2007	8.10	25.55	33.65	$106.27	$439.27	$545.54
2008	8.09	25.76	33.85	$107.62	$437.31	$544.93
2009	8.08	25.76	33.84	$106.98	$435.55	$542.54
2010	8.08	25.76	33.84	$106.67	$433.70	$540.36
2011	8.08	25.76	33.84	$106.39	$431.76	$538.15
2012	8.08	25.76	33.84	$105.83	$429.68	$535.50

Table 208-26c provides the breakdown of costs between seat belts and frontal air bags for passenger cars and LTVs. Pretensioners, load limiters and adjustable anchors have been added in with seat belts and manual on-off switches have been added in with air bags. In MY 2012, when there are no more manual on-off switches, the cost of frontal air bags is the same for passenger cars and LTVs, but the cost of seat belts is higher for LTVs because they have more seating positions on average than passenger cars.

Table 208-26c						
Summary Table of Consumer Costs - Seat Belts Versus Air Bags						
Passenger Cars and LTVs						
Model Year	**Passenger Cars**			**LTVs**		
	Seat Belts	**Air Bags**	**Total**	**Seat Belts**	**Air Bags**	**Total**
1968	$113.98	$0.00	$113.98	$70.54	$0.00	$70.54
1969	$114.18	$0.00	$114.18	$70.45	$0.00	$70.45
1970	$113.98	$0.00	$113.98	$70.34	$0.00	$70.34
1971	$113.79	$0.00	$113.79	$70.24	$0.00	$70.24
1972	$145.18	$0.00	$145.18	$104.03	$0.00	$104.03
1973	$147.98	$0.00	$147.98	$103.58	$0.00	$103.58
1974	$155.27	$0.00	$155.27	$106.98	$0.00	$106.98
1975	$155.33	$0.00	$155.33	$106.83	$0.00	$106.83
1976	$154.86	$0.00	$154.86	$106.45	$0.00	$106.45
1977	$151.68	$0.00	$151.68	$121.30	$0.00	$121.30
1978	$151.35	$0.00	$151.35	$120.59	$0.00	$120.59
1979	$150.89	$0.00	$150.89	$119.88	$0.00	$119.88
1980	$150.75	$0.00	$150.75	$120.12	$0.00	$120.12
1981	$152.45	$0.00	$152.45	$120.04	$0.00	$120.04
1982	$150.02	$0.00	$150.02	$119.61	$0.00	$119.61
1983	$148.93	$0.00	$148.93	$119.15	$0.00	$119.15
1984	$145.76	$0.00	$145.76	$118.63	$0.00	$118.63
1985	$143.60	$0.56	$144.16	$118.12	$0.00	$118.12
1986	$141.79	$2.71	$144.51	$117.62	$0.00	$117.62
1987	$163.16	$4.78	$167.94	$131.12	$0.00	$131.12
1988	$181.07	$5.94	$187.01	$130.76	$0.00	$130.76
1989	$194.86	$14.94	$209.80	$130.53	$0.00	$130.53
1990	$275.05	$108.53	$383.58	$130.15	$0.00	$130.15
1991	$269.24	$126.52	$395.76	$129.78	$0.00	$129.78
1992	$223.54	$185.58	$409.11	$128.77	$45.77	$174.54
1993	$227.04	$237.24	$464.28	$129.26	$67.72	$196.99
1994	$197.00	$369.53	$566.54	$128.55	$124.28	$252.83
1995	$160.75	$472.52	$633.28	$153.06	$310.15	$463.21
1996	$147.89	$480.28	$628.17	$152.45	$397.80	$550.25
1997	$141.19	$470.73	$611.92	$155.44	$430.33	$585.77
1998	$151.18	$451.72	$602.90	$161.03	$464.94	$625.97
1999	$157.02	$432.79	$589.81	$164.25	$445.91	$610.15
2000	$163.96	$413.74	$577.70	$166.48	$426.64	$593.12
2001	$171.88	$394.87	$566.75	$175.34	$406.60	$581.94
2002	$173.93	$375.84	$549.77	$182.41	$384.27	$566.68

2003	$175.59	$356.82	$532.42	$187.33	$361.96	$549.29
2004	$178.21	$399.04	$577.25	$190.49	$403.53	$594.02
2005	$180.09	$381.14	$561.23	$194.39	$382.77	$577.16
2006	$185.10	$363.41	$548.51	$195.20	$364.70	$559.91
2007	$184.22	$345.90	$530.12	$199.07	$346.47	$545.54
2008	$182.76	$343.83	$526.59	$200.71	$344.22	$544.93
2009	$182.13	$342.24	$524.38	$200.13	$342.41	$542.54
2010	$181.61	$340.56	$522.17	$199.61	$340.76	$540.36
2011	$181.07	$338.84	$519.91	$199.11	$339.04	$538.15
2012	$180.47	$336.98	$517.45	$198.52	$336.98	$535.50

FMVSS No. 211 – [Does not currently exist]

FMVSS No. 212, Windshield mounting

FMVSS No. 212 took effect on January 1, 1970, (passenger cars) and September 1, 1978 (multipurpose passenger vehicles, trucks, buses) and establishes windshield retention requirements for motor vehicles during crashes. The purpose of this standard is to reduce crash injuries and fatalities by providing for retention of the vehicle windshield during a crash, thereby using fully the penetration-resistance and injury-avoidance properties of the windshield glazing material and preventing the ejection of occupants through the windshield. This standard applies to passenger cars, multipurpose passenger vehicles, trucks, and buses having a GVWR of 10,000 pounds or less. However, it does not apply to forward control vehicles, walk-in van-type vehicles, or to open-body type vehicles with fold-down or removable windshields.[163]

The standard requires that a vehicle traveling longitudinally forward at any speed up to and including 30 miles per hour impacts a fixed collision barrier that is perpendicular to the line of travel of the vehicle, the windshield mounting of the vehicle shall retain not less than the minimum portion of the windshield periphery specified in the following:

- Vehicles equipped with automatic restraint systems shall retain not less than 50 percent of the portion of the windshield periphery on each side of the vehicle longitudinal centerline.
- Vehicles not equipped with automatic restraint systems shall retain not less than 75 percent of the windshield periphery.

[163] Kahane, C. J. (1985, February). *An evaluation of windshield glazing and installation methods for passenger cars.* (Report No. DOT HS 806 693). Washington, DC: National Highway Traffic Safety Administration. Available at www-nrd.nhtsa.dot.gov/Pubs/806693.pdf

Before 1963, windshields were sealed inside a rubber gasket or molding that in turn was attached and sealed to the frame. It was a relatively loose attachment. In low speed impacts, the rubber gasket had some energy absorbing give. At higher speeds, the gasket could partly or completely tear away from the frame, beginning during the initial vehicle collision and deformation and continuing as occupants impacted the windshield.

Bonding of the windshield directly to its frame with adhesives gradually (1963-1985) superseded the earlier method of first enclosing the windshield in a rubber gasket and then attaching the gasket to the frame. Adhesive bonding resembles HPR windshields in that it is primarily a technical advance, the synthesis of resilient sealing materials, than an addition of hardware to the car. The new bonding materials allowed the elimination of rubber gaskets in return for an inexpensive sealant and a minor increase in labor costs. Thus, the shift to adhesive bonding began in some vehicles well before anybody anticipated FMVSS No. 212, but rubber gaskets persisted in other make-models for quite a few years after the standard. Although rubber gaskets are generally a looser installation than adhesive bonding, they can readily be designed to meet FMVSS No. 212. Each installation method has advantages, and the gradual shift from one to the other was motivated by various factors, sometimes including FMVSS No. 212. However, vehicle manufacturers could meet the standard with either method.

Pickup trucks, vans, and SUVs also kept rubber gaskets during most of the 1970s, and in many cases after FMVSS No. 212 was extended to LTVs (September 1, 1978). Manufacturers may have been especially concerned that operation on rough roads could accelerate deterioration of adhesive bonds, as compared to rubber gaskets. Adhesive bonding was gradually phased in from 1978 to approximately 1985. The final transition to adhesive bonding may have been spurred by anticipation of safety benefits, cost advantages with the second-generation sealants, and a 1976 rule allowing NHTSA to conduct the FMVSS No. 212 test in a wider range of temperatures, from 15 to 110 degrees Fahrenheit.

A 1980 study compared rubber gaskets to adhesive bonding in one passenger car and three LTVs.[164] Table 212-1 shows the arithmetic average weight and consumer cost for the windshield mountings.

TABLE 212-1
AVERAGE WEIGHT AND CONSUMER COST
FOR WINDSHIELD MOUNTINGS IN PASSENGER VEHICLES

MATERIAL	WEIGHT IN POUNDS	CONSUMER COST ($2012)
Rubber Gasket	5.92	$43.84
Adhesive Bonding	0.69	$15.57

The substantial decrease in weight and consumer cost, when using adhesive bonding, cannot be attributed to the standard. Manufacturers could have moved to the use of the less costly adhesive bonding even without the standard. Furthermore, adhesive bonding was in common use on windshields long before the standard was proposed and rubber gaskets continued to be used for some years after the standard took effect. Because weight and costs were less with adhesive

[164] McLean, Eckel, & Leszchik, 1980), Docket No. 2011-0066-0071.

bonding and the standard did not require manufacturers to change to adhesive bonding, no weight and cost have been assigned to FMVSS No. 212.

Ford Motor Company in comments on the NHTSA evaluation report of FMVSS No. 205/212 questioned whether the preceding cost analysis realistically accounted for the full cost of adhesive bonding. Ford stated to achieve an acceptable appearance with adhesive bonding, interior and exterior moldings must be added to hide the bond area. In addition, a blackout paint band is generally added to the periphery of the glazing to block vision of the bond area and the underside of the trim moldings. As a result, adhesive bonding results in a cost and weight penalty, except on some luxury models and convertibles that have interior and exterior trim moldings installed for other reasons.[165]

FMVSS No. 213, Child restraint systems

FMVSS No. 213 took effect on April 1, 1971, and specifies requirements for child restraint systems used in motor vehicles and aircraft. The purpose of this standard is to reduce the number of children killed or injured in motor vehicle crashes and in aircraft. This standard applies primarily to aftermarket equipment that may be purchased for use in a vehicle, rather than to the vehicle itself. However, there were a small percentage of passenger cars (mostly Volvos) and a slightly larger percentage of LTVs (mainly minivans) that had built-in child restraints in the second seat. Typically, built-in child restraints were provided as optional equipment. Built-in child restraints were not required, but were allowed by FMVSS No. 213, and could be considered voluntary compliance. However, no cost studies of this standard have been done, and none are planned by NHTSA.

FMVSS No. 214, Side impact protection

FMVSS No. 214 took effect on January 1, 1973, and specified performance requirements for protection of occupants in side impact crashes. The purpose of this standard is to reduce the risk of serious and fatal injury to occupants of passenger cars, multipurpose passenger vehicles, trucks, and buses in side impact crashes. FMVSS No. 214 has been significantly upgraded twice since its inception as a quasi-static crush test. First, FMVSS No. 214 set strength requirements for doors, effective January 1, 1973, in passenger cars and extended to pickup trucks, vans, buses and SUVs of 10,000 pounds or less GVWR, effective September 1, 1993. Next, it added a dynamic crash test requirement, phased in for passenger cars from September 1, 1993, to September 1, 1996, and effective for LTVs up to 6,000 pounds GVWR on September 1, 1998. Most recently, it added a crash test of a 20 mph side impact with a pole, with phase-in scheduled from September 1, 2010, to September 1, 2014, for both passenger cars and LTVS.

Each of these upgrades addressed different types of side impacts and/or different modes of injury and did not replace the need for vehicles to meet the previous tests. As of 2012 it does not appear that side door beams were redesigned or that the structure or padding used to meet the dynamic test were decreased when torso bags and window curtains were used to meet the pole test. Thus, the countermeasures used to meet these three tests are discussed separately, with three separate

[165] Ford Motor Company. (1985, July 23). *Request for Comment on Evaluation Report on Federal Motor Vehicle Safety Standards 205/212*. (Correspondence). Dearborn, MI.

learning curves, and then added together to determine the total added weight and cost of FMVSS No. 214.

This standard is associated with three vehicle modifications whose weight and cost impacts have been evaluated by NHTSA.

- **Side door beams**
- **TTI(d) improvement in passenger cars by structure and padding**
- **Window curtain and side air bags**

The outline of the FMVSS No. 214 discussion below is to discuss side door beams for passenger cars, side door beams for LTVs, TTI(d) improvements for passenger cars, TTI(d) improvements for LTVs, and finally window curtain and side air bags for passenger cars and LTVs together.

Side Door Beams to meet the Quasi-Static test

Passenger Cars – Side Door Beams. FMVSS No. 214 originally specified performance requirements, effective January 1, 1973, for each side door in a passenger car to mitigate occupant injuries in side impacts by reducing the extent to which the side structure of a car is pushed into the passenger compartment during a side impact. On October 30, 1970, (35 FR 16801) a final rule was published in the Federal Register establishing FMVSS No. 214 (side door strength, passenger cars). The NPRM was published in the Federal Register on December 11, 1968, (33 FR 18386) making the baseline date September 1, 1968, or MY 1969. An estimated 17.64 percent of the fleet had side door beams in MY 1969. Thus, the 17.64 percent will be considered voluntary for MY 1969 and the voluntary percentage will be held at that MY 1969 baseline level through MY 2012. Attributable costs will be the difference between the installation rates for MY 1970 to MY 2012 minus the voluntary baseline level of MY 1969.

The standard initially specified a three-stage quasi-static[166] crush test (initial, intermediate, and peak) to measure the crush resistance of the side doors, and required each door to resist crush forces that are applied by a piston pressing a 12-inch diameter steel cylinder inward against the door's outside surface in a laboratory test.

Early studies concerning side impact protection demonstrated that in fatal side collisions most occupants die because of the door structures collapsing inward on them. The quasi-static crush tests were intended to ensure that there were strong door structures to limit this intrusion. Under the peak crush test, the vehicle door may not be deformed more than 18 inches inward when the door is subjected to a force of 7,000 pounds or two times the curb weight of the vehicle, whichever is less.[167] The standard, however, does not attempt to regulate directly the level of crash forces on an occupant who strikes or is struck by the car's interior during a side impact crash. Since the standard took effect on January 1, 1973, vehicle manufacturers have generally

[166] This test is referred to as a quasi-static test because the cylinder moves (so it is not a purely static test) but at such a slow rate that it does not have a dynamic aspect to the test.
[167] The standard was amended on March 17, 1980, to add a new door crush test (a 3-stage crush test) allowing the seats to be installed during the test. In this test, the peak force is 3.5 times the curb weight or 12,000 pounds, whichever is smaller.

chosen to meet its performance requirements by reinforcing the side doors with metal beams. The added side door beam helps to make a pole, tree, guardrail, or other fixed object slide by the occupant's position, thus reducing intrusion into the passenger compartment.

The side door beam of that era was a metal bar of channel design, typically 8 inches wide and with channels 2 inches deep. It was located inside each side door, close to the outside surface, about 10 inches above the sill. It ran the length of the door, being attached to the door frame vertical members at the hinge and latch ends of the door, and it may have been accompanied by local reinforcement of the B-pillar at the floor level.

Three cost and weight analyses were performed on side door beams and body pillars from 23 make-model 2-door passenger cars and 14 make-model 4-door passenger cars representing implementation and trend systems from 1973 to 1981.[168] [169] [170] (Changes in the body pillars discussed in the October 1978 study were a result of model redesign and not directly related to the standard, therefore, the weight and consumer cost for them were not included in the side door strength calculations). Table 214-1 shows the sales-weighted average weight and consumer cost for the side door beams in two- and 4-door passenger cars.

TABLE 214-1
AVERAGE WEIGHT AND CONSUMER COST PER VEHICLE OF SIDE DOOR BEAMS IN 2- AND 4 -DOOR PASSENGER CARS FROM COST TEARDOWN STUDIES

MODEL YEAR	WEIGHT IN POUNDS	CONSUMER COST ($2012)
2-Door		
1973	33.39	$61.11
1975-1978	23.90	$47.47
1979-1981	28.17	$55.58
4-Door		
1973	43.53	$109.31
1975-1979	26.60	$90.14
1979-1981	23.98	$65.13

For MYs 1975-1979, some design refinement had occurred with the door beams for the 4-door models, with more refinement occurring with the 1980 models. All through the late 1970s and early 1980s, downsizing was occurring and vehicle designs were incorporating design features into the vehicle bodies to cope with requirements and relying less on just door beams, consequently, door beams were becoming lighter and less costly.

In the 4-door passenger cars, the refinements and downsizing resulted in a 45 percent decrease in weight from 1973 to 1979-1981, with the 1979-1981 weight less than the weight for the 2-door

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[168] McLean, Eckel, & Cowan, DOT HS 803 871:22-37, 1978), Docket No. 2011-0066-0082.
[169] Harvey, M. R., & Eckel, C. E. (1979, November). *Cost evaluation for nine Federal Motor Vehicle Safety Standards, Task IX: Side door strength, identification and cost evaluation of design and manufacturing changes*. (Report No. DOT HS 805 450) Washington, DC: National Highway Traffic Safety Administration, Docket No. 2011-0066-0072.
[170] Gladstone, Harvey & Lesczhik, 1982), Docket No. 2011-0066-0066.

models. The cost for the 4-door models decreased 40 percent in the same time period; however, the 1979-1981 costs were still greater than the 2-door models. The costs and weights of the 1975-1979 models are lower than in 1973 and higher than in 1979-1981.

While the 2-door models saw a decrease of 28 percent in weight and 22 percent in cost from 1973 to 1975-1978, there was an increase of 18 percent in weight and 17 percent in cost from 1975-1978 to 1979-1981. This may be an artifact of the specific make-models selected for the 1975-1978 study. Notwithstanding this exception, there appears to be a general downward trend from 1972 to 1979-1981 in both the 2- and 4-door passenger cars.

Sales of 2-door and 4-door passenger cars changed dramatically over the time period. Two-door cars peaked in 1974 with 64 percent of the market and almost continuously lost market share to 4-door cars and hit a low of 11 percent of the market in 2011. We examined 2-door and 4-door passenger cars separately, and then combined them by the distribution of 2-door and 4-door vehicles in the fleet for each model year separately. Changes in weight from MY 1973 to 1981 were assumed to be linearly decreasing. The learning curve using the 1979 data matched the earlier teardown data very well for 2-door cars, but did not match the cost estimates for MY 1973 or MY 1975-8 vehicles. Thus, for 4-door cars the teardown data was used through MY 1981 and the learning curve was applied past that point. The average weight and consumer cost of the side impact protection to the quasi-static requirements of the standard in any given model year are shown in Table 214-2 as well as the percentage of passenger cars that were 2-door models.

Table 214-2
Weight (lb) and Consumer Cost (2012$)
To the Quasi-Static Test Met by Side Door Beams - Passenger Cars
Weighted by 2-Door and 4-Door Models

Model Year	% 2-Doors	Weight (lb)			Consumer Cost (2012$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0	0	0	0	$0.00	$0.00	$0.00
1969	54.82	6.70	0	6.70	$16.77	$0.00	$16.77
1970	57.94	6.64	6.98	13.62	$15.77	$16.57	$32.34
1971	58.43	6.63	9.93	16.56	$15.23	$22.80	$38.03
1972	56.14	6.67	11.99	18.67	$15.08	$27.09	$42.17
1973	57.79	6.65	25.38	32.03	$14.60	$55.77	$70.37
1974	64.32	6.22	29.06	35.29	$13.24	$61.81	$75.04
1975	61.32	5.95	27.77	33.72	$12.63	$58.96	$71.58
1976	60.91	5.64	26.31	31.94	$12.50	$58.38	$70.89
1977	59.15	5.32	24.83	30.15	$12.48	$58.26	$70.74
1978	58.51	4.99	23.30	28.29	$12.41	$57.96	$70.38
1979	59.96	4.67	21.82	26.49	$10.48	$48.92	$59.40
1980	58.06	4.66	21.75	26.41	$10.45	$48.80	$59.25
1981	49.72	4.60	21.47	26.06	$10.56	$49.29	$59.84
1982	45.83	4.57	21.33	25.90	$10.43	$48.68	$59.11

1983	41.07	4.53	21.17	25.70	$10.42	$48.64	$59.05
1984	41.56	4.54	21.18	25.72	$10.32	$48.18	$58.49
1985	38.59	4.52	21.08	25.60	$10.28	$47.99	$58.27
1986	37.42	4.51	21.04	25.55	$10.21	$47.68	$57.90
1987	34.93	4.49	20.96	25.44	$10.18	$47.54	$57.72
1988	37.78	4.51	21.05	25.56	$10.07	$47.02	$57.09
1989	38.32	4.51	21.07	25.59	$10.01	$46.71	$56.72
1990	32.97	4.47	20.89	25.36	$10.04	$46.86	$56.89
1991	31.77	4.46	20.85	25.31	$10.01	$46.73	$56.74
1992	27.78	4.44	20.71	25.14	$10.02	$46.80	$56.83
1993	28.35	4.44	20.73	25.17	$9.97	$46.55	$56.52
1994	27.95	4.44	20.71	25.15	$9.91	$46.25	$56.16
1995	26.03	4.42	20.65	25.07	$9.87	$46.09	$55.97
1996	23.50	4.40	20.56	24.96	$9.85	$45.99	$55.84
1997	21.57	4.39	20.49	24.88	$9.82	$45.85	$55.68
1998	19.61	4.38	20.43	24.80	$9.79	$45.73	$55.52
1999	19.73	4.38	20.43	24.81	$9.74	$45.46	$55.19
2000	19.08	4.37	20.41	24.78	$9.69	$45.24	$54.93
2001	18.66	4.37	20.39	24.76	$9.65	$45.03	$54.68
2002	17.68	4.36	20.36	24.72	$9.61	$44.88	$54.49
2003	15.87	4.35	20.30	24.64	$9.59	$44.79	$54.38
2004	17.21	4.36	20.34	24.70	$9.53	$44.49	$54.02
2005	14.33	4.34	20.24	24.58	$9.53	$44.49	$54.02
2006	15.08	4.34	20.27	24.61	$9.48	$44.26	$53.74
2007	14.26	4.34	20.24	24.58	$9.45	$44.14	$53.60
2008	14.53	4.34	20.25	24.59	$9.42	$43.99	$53.41
2009	14.65	4.34	20.26	24.59	$9.40	$43.88	$53.28
2010	13.51	4.33	20.22	24.55	$9.39	$43.84	$53.23
2011	10.81	4.31	20.12	24.43	$9.40	$43.90	$53.30
2012	12.29	4.32	20.17	24.49	$9.35	$43.67	$53.03

LTVs – Side Door Beams. The number of LTV occupant fatalities increased during the 1980s primarily due to the greatly increasing sales of these vehicles and their use for passenger transportation. Side impacts were a significant cause of these fatalities. Consequently, NHTSA extended the side door strength requirements of FMVSS No. 214 to LTVs with a GVWR of 10,000 pounds or less starting September 1, 1993. The final rule was published in the Federal Register on June 14, 1991, (56 FR 27427) extending FMVSS No. 214 side door strength requirement to LTVs. The NPRM was published in the Federal Register on December 22, 1989, (54 FR 52826) making the baseline date September 1, 1989, or MY 1990.

Prior to MY 1991, some door reinforcement was already present. However, manufacturers responded by adding reinforcement beams to the doors, perhaps along with very minor strengthening of the A and B pillars around the door hinge and door latch areas. Since manufacturers responded to the rulemaking by adding structure, and we only cost estimated that added structure, none of the incremental costs are considered in the baseline fleet and all costs are attributable to the standard. A study conducted in 1998 looked at the side safety systems from five pre-standard (1987) make models and five corresponding post-standard (1994) make-model LTVs.[171] The cost teardown analysis determined that the A and B pillar in both the pre- and post-standard LTVs had the same weight and cost; consequently, changes made to meet the standard were incorporated into the door only.

Table 214-3 shows the arithmetic average weight and consumer cost of the safety equipment such as side door beams and supporting structures contained in pre- and post-standard side doors. Other functional and cosmetic components of the doors, such as sheet metal, window systems, and interior decoration are not included. Our customary methodology is to attribute only the difference between pre- and post-standard, 15 pounds and $18.15, to FMVSS No. 214 and not the full weight and cost of the safety equipment in the post-standard vehicles, 23.76 pounds and $36.34, to FMVSS No. 214.

TABLE 214-3
AVERAGE INCREMENTAL WEIGHT AND CONSUMER COST OF SIDE IMPACT PROTECTION
QUASI-STATIC TEST
FOR FMVSS No. 214 IN LTVS

COMPONENT	WEIGHT IN POUNDS	CONSUMER COST ($2012)
Front Side Door	15.00	$18.15

Table 214-4 provides the estimated incremental weight and cost for the quasi-static test for FMVSS No. 214 for LTVs after applying the learning curve.

[171] Fladmark, G. L., & Khadilkar, A. V. (1998, September). *Cost estimates of side impact crash protection of 1994 vs. pre-standard 214 (static test – side impact) LTVs* (Report No. DOT HS 809 804). Washington, DC: National Highway Traffic Safety Administration, Docket No. 2011-0066-0018.

Table 214-4							
Average Weight and Cost (2012$)							
Quasi-Static Test for FMVSS No. 214							
LTVs							
Model Year	% Installed	Weight (lb)			Consumer Cost (2012$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
1990	0	0	0	0	$0.00	$0.00	$0.00
1991	11.44	0	1.72	1.72	$0.00	$2.11	$2.11
1992	12.71	0	1.91	1.91	$0.00	$2.33	$2.33
1993	18.88	0	2.83	2.83	$0.00	$3.45	$3.45
1994	100	0	15.00	15.00	$0.00	$18.15	$18.15
1995	100	0	15.00	15.00	$0.00	$18.03	$18.03
1996	100	0	15.00	15.00	$0.00	$17.92	$17.92
1997	100	0	15.00	15.00	$0.00	$17.82	$17.82
1998	100	0	15.00	15.00	$0.00	$17.72	$17.72
1999	100	0	15.00	15.00	$0.00	$17.61	$17.61
2000	100	0	15.00	15.00	$0.00	$17.51	$17.51
2001	100	0	15.00	15.00	$0.00	$17.42	$17.42
2002	100	0	15.00	15.00	$0.00	$17.33	$17.33
2003	100	0	15.00	15.00	$0.00	$17.25	$17.25
2004	100	0	15.00	15.00	$0.00	$17.17	$17.17
2005	100	0	15.00	15.00	$0.00	$17.10	$17.10
2006	100	0	15.00	15.00	$0.00	$17.03	$17.03
2007	100	0	15.00	15.00	$0.00	$16.96	$16.96
2008	100	0	15.00	15.00	$0.00	$16.91	$16.91
2009	100	0	15.00	15.00	$0.00	$16.87	$16.87
2010	100	0	15.00	15.00	$0.00	$16.83	$16.83
2011	100	0	15.00	15.00	$0.00	$16.78	$16.78
2012	100	0	15.00	15.00	$0.00	$16.73	$16.73

Structure and Padding Improvements to meet FMVSS No. 214 Upgrade – Dynamic Test Requirement and TTI(d).

Passenger Cars – Dynamic Test. NHTSA's analysis of real-world crash data showed that strengthening the side doors with metal beams was indeed effective in single-vehicle crashes but had little effect on reducing fatalities in multi-car crashes.[172] Consequently, FMVSS No. 214 was amended in October 1990 to upgrade its test procedures and performance requirements for passenger cars.

The amendments required that each passenger car, in addition to the quasi-static crush performance requirements, must protect its occupants in a full-scale dynamic crash test in which the passenger car is struck on either side by a moving deformable barrier simulating another vehicle. Instrumented test dummies are positioned in the target car to measure the potential for injuries to an occupant's torso and pelvis. Accelerations at the dummy's upper rib, lower rib, and lower spine are measured, and a Thoracic Trauma Index on the dummy, TTI(d) is calculated from these accelerations. Four-door passenger cars must score 85 or less, while 2-door passenger cars must score 90 or less. In addition, the pelvis acceleration must be less than 130 g's. However, the safety benefits are mainly from chest injury reduction. The requirements were phased in with 10 percent of new passenger cars in MY 1994, 25 percent in 1995, 40 percent in 1996, and 100 percent in 1997 (i.e., after September 1, 1996).

On October 30, 1990, (55 FR 45721) a final rule was published in the Federal Register upgrading FMVSS No. 214, adding a dynamic side impact test for passenger cars. The NPRM was published in the Federal Register on January 27, 1988, (53 FR 2239) making the baseline date September 1, 1987, or MY 1988. Since the costs for dynamic side impact testing are over and above the baseline vehicles that meet the quasi-static test, and we have no test data indicating what percent of MY 1988 vehicles met the dynamic side impact test, we assume no voluntary compliance during the baseline year. Even if we knew that some vehicles met the test in the baseline year, we have no data indicating what countermeasures were provided on those vehicles, as opposed to just being large vehicles that met the standard by structure alone, and what the costs of those voluntarily provided countermeasures might be. So, we can't make an estimate of voluntary weight or cost provided in years before the baseline or even up to MY 1993. Our compliance estimates start with MY 1994, where we have data from the manufacturers that was used to certify compliance with the MY 1994 phase-in.

Manufacturers initially relied on one or more of the following strategies to ensure their vehicles met the dynamic test.

- No changes necessary to meet the dynamic test
- Major structure changes applied to the A-pillars, the front and rear door or rear panel (2-door models), the B-pillar, the C-pillar, or other components
- Minor structure changes such as additional or strengthened door beams and some additional steel plates
- Padding added to inside of door skin or inner door structure

NHTSA sent information requests to vehicle manufacturers asking them to identify any components that were added or redesigned to meet the dynamic performance requirements. The

[172] Kahane, C. J. (1982, November). *An evaluation of side structure improvements in response to Federal Motor Vehicle Safety Standard 214* (Report No. DOT HS 806 314). Washington, DC: National Highway Traffic Safety Administration. Available at www-nrd.nhtsa.dot.gov/Pubs/806314.pdf

requests were reviewed to determine which alternative the vehicle manufacturers chose, and it is our belief that an estimated 56 percent of the vehicles certified to comply with this requirement had substantial structural reinforcement changes and added padding, 21 percent had minor structural changes and added padding, 6 percent just added padding to comply, while 17 percent of the vehicles had no structural changes or added padding.[173] Of course, all vehicles continued to have side door beams and other equipment previously installed to meet the original, quasi-static requirement of FMVSS No. 214.

Since our teardown cost analysis was limited to a sample of nine vehicles that all had major structure changes, a simple average of these teardowns would be a substantial overestimate of the cost of FMVSS No. 214. Therefore, to calculate a realistic cost of the standard, it was necessary to generate estimates for the vehicles that did not have major structure changes, append those estimates to the contractor's costs, and average the results.

Here is a more detailed discussion of the cost implications of the alternative methods to secure compliance with FMVSS No. 214.

- No Structural Changes or Padding. Some vehicles did not have to incorporate any structural changes or added padding to their vehicles to meet the dynamic standard. Of course, even in these vehicles, the equipment used to meet the quasi-static requirement would continue to be in place. Therefore, the full cost and weight of FMVSS No. 214 would be equal to the weight and consumer cost from the study of the two- and 4-door passenger cars from 1979 to 1981. These results for these quasi-static requirements, before applying the learning curve are shown in Table 214-5.

TABLE 214-5
AVERAGE WEIGHT AND CONSUMER COST OF FMVSS No. 214 IN 2- AND 4 -DOOR PASSENGER CARS THAT REMAINED UNCHANGED

CAR TYPE	WEIGHT IN POUNDS	CONSUMER COST ($2012)
2-Door	28.17	$55.58
4-Door	23.98	$65.13

- Major Structure Changes with Padding. Substantial structural changes were applied to the A-pillars, the front and rear door or rear panel (2-door models), the B-pillar, and the C-pillar. The changes to the pillars were to help support the loads on the door hinges and latches and provide additional structural rigidity so that impact loads could be transferred to the rest of the vehicle body without buckling. In some cases, a dashboard level cross-member between left and right A-pillars was added. Floor cross-members linking the left and right B-pillars were added or strengthened and the same was done for the C-pillars. Changes to the doors and rear panels (2-door models) typically consisted of additional door beams and energy absorbing designs in the inner door structure. Three cost and weight analyses comprised two make-model 2-door passenger cars and seven make-

[173] Kahane, C. J. (1999, October). *Evaluation of FMVSS 214 side impact protection, dynamic performance requirement* (Report No. DOT HS 809 004). Washington, DC: National Highway Traffic Safety Administration.

model 4-door passenger cars representing systems from 1994-1998.[174,175,176] For the learning curve calculations, we will assume these costs represent MY 1996 vehicles. These contractor reports attempted to estimate separately the cost and weight of equipment needed only to meet the dynamic standard versus equipment needed to meet the quasi-static requirement. However, we have added these costs and weights to produce a single, more consistent and reliable estimate of the total cost and weight of FMVSS No. 214. Table 214-6 shows the arithmetic average total weight and consumer cost of the side impact protection system (dynamic and quasi-static requirements) in two- and 4-door passenger cars in MY 1994-98.

TABLE 214-6
AVERAGE WEIGHT AND CONSUMER COST
OF FMVSS No. 214 (DYNAMIC PLUS QUASI-STATIC REQUIREMENTS)
IN 2- AND 4 -DOOR PASSENGER CARS
WITH MAJOR STRUCTURE CHANGES

CAR TYPE	WEIGHT IN POUNDS	CONSUMER COST $2012
2-Door	70.33	$274.78
4-Door	90.59	$335.27

- Cost and Weight of Padding. Padding was typically affixed to the inside of the door skin or inner door structure. The foam padding was strategically placed with one piece to protect the upper and lower rib cage of the occupant and other piece located to protect the pelvis. As stated above, the contractor did not teardown any vehicles whose modifications were limited to padding. Therefore, we reviewed the contractor's nine teardowns of vehicles that received padding plus major structure and isolated the costs specifically related to padding. Next, we compared the padding in these vehicles to padding in vehicles that did not receive major structure, and found them quite similar in size and shape. The component cost summaries, with corresponding photographs from the sample vehicles in the teardown cost studies, were analyzed and the padding information was extracted. The arithmetic average for the padding incorporated into the front door, rear door, and in some cases the B pillar was calculated for the 1994-1998 model year passenger cars. Table 214-7 shows the average weight and consumer cost of just the padding in the two- and 4-door passenger cars.

TABLE 214-7
AVERAGE WEIGHT AND CONSUMER COST
OF PADDING IN 2- AND 4 -DOOR PASSENGER CARS

CAR TYPE	WEIGHT IN POUNDS	CONSUMER COST $2012
2-Door	0.91	$ 12.16
4-Door	1.27	$ 17.21

- Cost and Weight of Minor Structure Changes. Minor structure changes usually consisted of additional or strengthened door beams and some additional steel plates added to strengthen areas on the pillars around the door latches and hinges. As stated above, teardowns were limited to vehicles with major structure changes. In order to estimate the

[174] Fladmark & Khadilkar, DOT HS 809 800, 1996, Docket No. 2011-0066-0022.
[175] Fladmark & Khadilkar,, DOT HS 809 803,1997, Docket No. 2011-0066-0019.
[176] Fladmark & Khadilkar, DOT HS 809 805,1998, Docket No. 2011-0066-0017.

cost of new structure in the 21 percent of vehicles that had only minor changes, we needed to: (1) establish some kind of ratio of the cost of minor to major structural changes; (2) isolate in the teardown sample the FMVSS No. 214 costs specifically associated with major structural changes, as opposed to, padding or continuation of the equipment needed to meet the quasi-static requirement; and (3) multiply the ratio of minor to major structure by the cost of major structure.

1) In the seven teardown vehicles for which we also had clear diagrams or enumerations of the new structure, we found an average of 4.43 relatively massive and costly new structural components per vehicle, such as large-size pillar stiffeners, cross members, beams, and sill reinforcements. Information requests to the manufacturers furnished detailed diagrams or enumerations of new structure in six make-models that we described above as receiving only minor structure. For the most part, these new structures were limited to a few very low-cost items such as small, localized beams and sills, but some models received one or even two massive and costly components. In all, these six make-models received an average of 0.83 massive and costly components per vehicle. Therefore, we estimate that the cost ratio of minor to major structure must have been close to 0.83/4.43 = 19 percent.

2) The top section of Table 214-8 shows an example of how the cost of minor structure was determined. Starting with the average cost of major new structure in the teardown vehicles (e.g., $335.27 in 4-door passenger cars from Table 214-6), deduct the cost or weight of padding (e.g., $17.21 from Table 214-7) and the cost or weight of the existing structures used for meeting the quasi-static requirements of FMVSS No. 214 (e.g., $65.13 from Table 214-5). The remainder ($252.92 in the 4-door passenger cars) is the cost of the added major structures.

3) Multiply the cost or weight of added major structures in the teardown sample by 19 percent to obtain an estimate of the cost or weight of added minor structures ($48.06), as shown in the lower section of Table 214-8.

TABLE 214-8
DETERMINATION OF THE
AVERAGE WEIGHT AND CONSUMER COST (2012$)
OF MINOR STRUCTURE CHANGES
IN 2- AND 4 -DOOR PASSENGER CARS

		2-DOOR		4 -DOOR	
	CATEGORY	WEIGHT	COST	WEIGHT	COST
	214 Teardown Studies	70.33	$274.78	90.59	$335.27
-	Padding	0.91	$ 12.16	1.27	$ 17.21
-	Quasi-Static Requirements	28.17	$ 55.58	23.98	$ 65.13
=	Major Structure	41.25	$207.04	65.34	$252.92
*	Percentage Change	0.19	0.19	0.19	0.19
=	Minor Structure	7.84	$ 39.34	12.41	$ 48.06

Table 214-8 shows the costs for each of the countermeasures alone. However, the vehicles that had both the major and minor structures also had padding. Table 214-9 shows the average weight and consumer cost of the side impact protection system in two- and 4-door passenger cars, broken out by the changes incorporated by the vehicle manufacturers. These are incremental costs to the quasi-static test requirements. It is necessary to add the cost of padding to the major and minor structures in the vehicles that have more than one of those items.

TABLE 214-9 AVERAGE WEIGHT AND CONSUMER COST OF FMVSS No. 214 (DYNAMIC REQUIREMENTS ALONE) IN ALL PASSENGER CARS			
CHANGED TO MEET DYNAMIC STANDARD	**WEIGHT IN POUNDS**	**CONSUMER COST ($2012)**	**PERCENT OF CARS**
2-Door			
Major Structure Changes + Padding	42.16	$219.20	56
Minor Structure Changes + Padding	8.75	$ 51.50	21
Padding	0.91	$ 12.16	6
Quasi-Static Only	0	$ 0.00	17
WEIGHTED AVERAGE	25.50	$134.29	
4-Door			
Major Structure Changes + Padding	66.61	$270.13	56
Minor Structure Changes + Padding	13.68	$ 65.26	21
Padding	1.27	$ 17.21	6
Quasi-Static Only	0	$ 0.00	17
WEIGHTED AVERAGE	40.25	$166.01	

For the learning curve analysis, separate learning curves are derived for 2-door cars using the $134.29 and a separate learning curve is derived for 4-door cars using $166.01 for MY 1996 vehicles, then they are weighted by the percentage of the fleet that is 2-door and 4-door cars that was shown in Table 214-2.

Table 214-10 shows the average weight and consumer cost for FMVSS No. 214 dynamic test for passenger cars by model year.

Table 214-10						
Weight (lb) and Consumer Cost (2012$)						
FMVSS No. 214 Dynamic Test for Passenger Cars						
Weighted by 2-Door and 4-Door Models						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1993	0	0	0	0	0	0
1994	0	6.60	6.60	$0.00	$34.95	$34.95
1995	0	15.06	15.06	$0.00	$70.34	$70.34
1996	0	23.75	23.75	$0.00	$102.36	$102.36
1997	0	37.07	37.07	$0.00	$149.94	$149.94
1998	0	37.36	37.36	$0.00	$145.02	$145.02
1999	0	37.34	37.34	$0.00	$140.83	$140.83
2000	0	37.44	37.44	$0.00	$137.79	$137.79
2001	0	37.50	37.50	$0.00	$135.44	$135.44
2002	0	37.64	37.64	$0.00	$133.71	$133.71
2003	0	37.91	37.91	$0.00	$132.55	$132.55
2004	0	37.71	37.71	$0.00	$130.77	$130.77
2005	0	38.14	38.14	$0.00	$130.19	$130.19
2006	0	38.03	38.03	$0.00	$128.80	$128.80
2007	0	38.15	38.15	$0.00	$127.93	$127.93
2008	0	38.11	38.11	$0.00	$126.98	$126.98
2009	0	38.09	38.09	$0.00	$126.29	$126.29
2010	0	38.26	38.26	$0.00	$125.92	$125.92
2011	0	38.66	38.66	$0.00	$125.91	$125.91
2012	0	38.44	38.44	$0.00	$124.80	$124.80

LTVs – Dynamic Test. Starting September 1, 1998, LTVs with a GVWR of 6,000 pounds or less were subject to the same dynamic requirements as the passenger cars. No teardown studies have been performed on the changes made as a result of this requirement. These LTVs would have a much greater probability than passenger cars of meeting the dynamic requirement without any changes. At the time this final rule was written, NHTSA believed that all LTVs would have met the final rule requirements without adding any weight or cost. Further support of this belief was a MY 1991 Toyota pickup that had a TTI(d) of 55, which was well below the 85 TTI(d) required, and an information request sent to manufacturers at the time NHTSA was evaluating FMVSS 214. The information request did not show any clear evidence of structural modification in ten MY 1999 pickup trucks.[177]

[177] Kahane, C. J. (2007, January). *An evaluation of side impact protection, FMVSS 214 TTI(d) improvements and side air bags* (Report No. DOT HS 810 748). Washington DC: National Highway Traffic Safety Administration.

Window curtain and side air bags to meet the pole test

Passenger car and LTV window curtains and side air bags are discussed together for ease of presentation.

During the 1990s, manufacturers and suppliers developed window curtain and side air bags to protect an occupant's head, torso and pelvis in side impacts – specifically near-side impacts to the side of the vehicle adjacent to where the occupant is seated – even more effectively than the structure and padding originally employed to meet FMVSS Nos. 201 and 214. Some window curtain air bags may also be designed to deploy in rollover crashes and/or to reduce an occupant's risk of complete or partial ejection from the vehicle in crashes, but these rollover window curtains are discussed in the chapter on FMVSS No. 226, Ejection mitigation. Side air bags were first offered in MY 1996 in the United States on 0.3 percent of vehicles sold that year.

On September 11, 2007, (72 FR 51908) a final rule was published in the Federal Register adding a pole test to FMVSS No. 214, Side impact protection for passenger cars and LTVs. The NPRM was published in the Federal Register on May 17, 2004, (69 FR 27990) making the baseline date September 1, 2003, or MY 2004. Costs will thus be considered voluntary through MY 2004 and the voluntary percentage will be held at that MY 2004 baseline level through MY 2012. Attributable costs will be the difference between the installation rates for MY 2005 to MY 2012 minus the voluntary baseline level of MY 2004.

Types of air bags: There are three major types of air bags designed to deploy in side impacts.

Torso air bags provide an energy-absorbing cushion between the occupant's torso and the vehicle's side structure during lateral impacts. They usually are built into the seat and deploy from there, but sometimes are built into the door. Some, but not all torso bags extend downward to also protect the pelvis. Volvo introduced torso bags in the United States, making them standard equipment on all their MY 1996 cars. Torso air bags mounted into the seat required seat structure redesign to accommodate the air bag module location, as well as foam and stitching changes to accommodate the torso air bag deployment.

Window curtain air bags are built into the roof-rail area above the side window and deploy downward to cover the window area. They provide a cushion between the occupant's head and some of the rigid surfaces of the vehicle interior, such as the roof rail, the window sill, the A-pillar, and the B-pillar. They might also prevent partial or complete ejection of the occupant through the side-window area and prevent direct occupant contact with the striking vehicle or object. Some early designs of window curtain bags had a limited longitudinal span, leaving a substantial portion of the window uncovered or they were inflatable tubular structures with a limited vertical span. Many recent window curtains cover a wide longitudinal and vertical span, including most of the side-window area and the harder structures around it. BMW introduced inflatable tubes for head protection, in combination with torso bags in their 1998 500-series and 700-series cars. In 1999, Mercedes E-series and Volvo S-80 were equipped with window curtains plus torso bags. Window curtains alone, without torso bags, did not appear until MY 2001, as options in some Chrysler, Dodge, and Saturn cars. Recently, suppliers have developed a head-impact air bag for use in convertibles; it covers an area similar to a window curtain, but deploys up from the door rather than down from the roof rail.

Combination bags are torso bags that deploy outward from the seat and then quickly upward to also provide head protection. Unlike window curtains, they cover a somewhat limited area immediately to the occupant's side. Combination bags were standard in 1999 on Lincoln Town Car and Continental and Infiniti Q45, G20, and QX4; also optional on some other Ford Motors cars and LTVs. By 2010, combination bags were limited primarily to convertibles, where there is no roof rail for installing a window curtain air bag.

The most extensive side-impact protection is the combined Window c***urtain plus torso bags.*** The window curtains are separate from the torso bags, although they usually share components such as sensors and the control module. By MY 2006, window curtain plus torso bags, the configuration that covers the largest area and intuitively appears to provide the most protection were the clear preference. In MY 2012, about 88 percent of new cars and LTVs were equipped with window curtain plus torso bags for drivers and right front passengers.

The September 11, 2007, the final rule upgrading FMVSS No. 214 by adding a crash test of a 20 mph side impact with a 10-inch diameter pole, at a 75-degree angle (i.e., 15 degrees forward of a purely lateral impact) essentially required side air bags to protect the head. Whether a torso bag was needed to meet the pole test or the dynamic test or neither was not as clear. The phase-in required compliance by:

20 percent of vehicles manufactured between September 1, 2009, and September 1, 2010.

50 percent of vehicles manufactured between September 1, 2010, and September 1, 2011.

75 percent of vehicles manufactured between September 1, 2011, and September 1, 2012.

100 percent of vehicles manufactured on or after September 1, 2012.

While no safety standard explicitly requires vehicles to have window curtain or side air bags, every manufacturer used these countermeasures to certify compliance to the pole test. NHTSA anticipated that head-protection air bags – i.e., window curtain bags if possible; combination bags or door-mounted head-impact bags in convertibles without a roof rail – would generally be installed to meet the new requirement, because they appeared to be the principal technology available for cushioning an occupant in oblique impacts.

The percentage of vehicles equipped with side air bags by model year was provided in the evaluation[178] of the fatality reduction by side air bags. These estimates were updated with another year of data for this report and passenger cars and LTVs were considered separately. The percentage of the fleet equipped with the different types of air bags are provided in Table 214-11 for passenger cars and LTVs by model year. For costing purposes, these are summed into three types of side air bags: torso bags, combination bags, and window curtains (combining both non-rollover and rollover window curtains). In FMVSS No. 226, we will count the incremental weight and cost for a rollover window curtain compared to a non-rollover window curtain. For FMVSS No. 214 we will only count the cost of the non-rollover window curtain.

[178] Kahane, C. J. (2014, January). *Updated estimates of fatality reduction by curtain and side air bags in side impacts and preliminary analyses of rollover curtains* (Report No. DOT HS 811 882). Washington, DC: National Highway Traffic Safety Administration.

Table 214-11 Percentage of Passenger Cars and LTVs With Different Types of Side Air Bags								
			Passenger Cars			LTVs		
Model Year	No Side Bags	Torso	Com-bination	Window Curtain	No Side Bags	Torso	Com-bination	Window Curtain
1996	99.51	0.49	0	0	100	0	0	0
1997	97.17	2.83	0	0	100	0	0	0
1998	91.03	8.97	0	0.49	97.78	2.22	0	0
1999	87.64	9.80	2.56	1.20	96.3	2.58	1.12	0
2000	77.92	15.23	6.85	1.72	91.42	6.35	2.23	0.05
2001	70.85	18.92	9.76	6.61	84.94	8.55	6.51	0.38
2002	68.73	19.87	10.02	9.39	75.54	18.2	4.55	2.23
2003	68.79	21.43	8.83	12.92	80.29	11.86	4.58	4.64
2004	65.83	23.37	8.80	18.43	76.74	14.56	3.59	10.23
2005	64.44	23.09	10.87	21.28	78.01	12.58	2.56	14.6
2006	50.60	33.75	9.21	38.40	74.87	17.48	1.68	20.31
2007	30.92	48.96	7.36	61.13	61.36	19.78	1.10	36.93
2008	12.34	68.99	6.89	80.16	51.39	28.03	2.02	46.59
2009	2.49	83.55	6.80	90.28	31.60	45.19	1.11	67.29
2010	0	88.73	5.79	94.10	11.37	69.62	2.11	86.52
2011	0	93.60	5.43	94.57	7.62	77.00	2.12	90.26
2012	0	99.60	0.40	99.60	7.60	77.30	2.10	90.30

Side air bag costs. Based on two cost teardown studies,[179] [180] NHTSA estimated the costs of side air bags in the Final Regulatory Impact Analysis.[181] We went back to the same cost teardown studies to identify the weights of side air bag systems. The weights and costs apply to both passenger cars and LTVs. No pattern was identified that would indicate that weights or costs were higher or lower for LTVs compared to passenger cars.

As with frontal air bags, side air bags also changed over time. Because of the oblique angle of

[179] Khadilkar, A. V., Fladmark, G. L., & Khadilkar, J. (2003, April). *Teardown cost estimates of automotive equipment manufactured to comply with motor vehicle standards, FMVSS 214(D)- side impact protection, side air bag features* (Report No. DOT HS 809 809, Docket No. 2011-0066-0009.

[180] Ludtke & Associates. (2004, December). *Perform cost and weight analysis, head protection air bag systems, FMVSS 201* (Report No. DOT HS 809 842, Docket No. 2011-0066-0007, Table 4-1, page 4-3). Washington, DC: National Highway Safety Administration. Mercury Monterey air bag not included because it was much heavier and costlier than others.

[181] NHTSA. (2007, August). *Final Regulatory Impact Analysis, FMVSS No. 214, Amending Side Impact Dynamic Test, Adding Oblique Pole Test*. Docket No. 2007-29134-0004.

the pole test and the requirement to pass the test with a 5th percentile female dummy in the forward seating position, many of the voluntarily provided torso, combination bags, and window curtain air bags were not wide enough to comply with the new oblique pole test. In addition, many vehicles needed two sensors per side of the vehicle to determine that a side impact with a narrow pole had occurred and the side air bags and window curtain should be deployed. Thus, we need two cost estimates for side air bags of all types, one that is pre-standard (up to MY 2009) and one for post-standard (MY 2009 and later) window curtains. Although many of the side air bags were not wide enough to meet the oblique pole test, these pre-standard side air bags did provide significant benefits to occupants. Side air bags and window curtains changed again with the evolution of the ejection mitigation window curtain. Ejection mitigation window curtains relate to the new FMVSS No. 226, and their weights and costs will be discussed in the section on FMVSS No. 226.

Table 214-12 provides the estimated cost increases by type of side air bag for both the pre-standard side air bags and the post-standard side air bags. The pre-standard side air bag 2-sensor cost estimates below are the basis for what is provided into the learning curve analysis, and then additions were made for the percentage of the fleet with 4 sensors and for the additional cost for post-standard side air bags for MY 2009 to MY 2012.

Table 214-12				
Weight and Consumer Cost (2012$) Before Learning Curve				
Side Impact Oblique Pole Test for Passenger Cars or LTVs				
Side Air Bags for Both Sides of the Vehicle				
2-sensors	**Pre-Standard Side Air Bags**		**Post-Standard Side Air Bags**	
Side Air Bag Type	Weight	Cost	Weight	Cost
Torso + Sensors	6.39	$122.59	6.90	$128.78
Combination + Sensors	7.09	$136.31	7.34	$148.68
Window Curtain Alone	6.78	$154.18	7.24	$157.89
Torso + Sensors	13.18	$276.77	14.14	$286.66
Plus Window Curtain				
4-sensors	**Pre-Standard Side Air Bags**		**Post-Standard Side Air Bags**	
Side Air Bag Type	Weight	Cost	Weight	Cost
Torso + Sensors	6.69	$165.79	7.19	$171.98
Combination + Sensors	7.39	$179.51	7.63	$191.88
Window Curtain Alone	6.78	$154.18	7.24	$157.89
Torso + Sensors	13.47	$319.97	14.43	$329.87
Plus Window Curtain				

Side impact sensors. To determine the percentage of the fleet that had 2 side impact sensors per vehicle versus 4 side impact sensors per vehicle, data on a make-model year basis was collected from the Holmatro data book.[182] This book, which can be purchased by subscription only, includes every make-model in the fleet and provides information on air bags and sensors. Data was collected and compared to make-model sales for MY 2001, MY 2005 and MY 2009. MY 2009 is the last year for which data are provided in this series of books. Given that a vehicle had side impact sensors, the percentage distribution between 2 sensors and 4 sensors per vehicle changed dramatically between MY 2001 and MY 2009. Other years from MY 1996 to MY 2012 were interpolated or extended from this data. Table 214-13 shows these results.

[182] Mitchell International, LLC, prepared for Holmatro, Inc. *The Rescuer's Guide to Vehicle Safety Systems, Seventh Edition, 1985-2009, Domestic and Imported Cars and Trucks.*

Table 214-13					
Side Impact Sensor Data					
For Passenger Cars and LTVs					
Percent Distribution Between 2 and 4 Sensor Vehicles, Given These Vehicles had Sensors					
Model	**Passenger Cars**			**LTVs**	
Year	**2 Sensors**	**4 Sensors**		**2 Sensors**	**4 Sensors**
1996	100.00%	0.00%		0.00%	0.00%
1997	98.08%	1.92%		0.00%	0.00%
1998	96.16%	3.84%		100.00%	0.00%
1999	94.24%	5.76%		93.80%	6.20%
2000	92.32%	7.68%		87.61%	12.39%
2001	90.39%	9.61%		81.41%	18.59%
2002	83.97%	16.03%		74.78%	25.22%
2003	77.55%	22.45%		68.15%	31.85%
2004	71.12%	28.88%		61.53%	38.47%
2005	64.70%	35.30%		54.90%	45.10%
2006	58.35%	41.65%		45.15%	54.85%
2007	52.00%	48.00%		35.40%	64.60%
2008	45.65%	54.35%		25.65%	74.35%
2009	39.30%	60.70%		15.90%	84.10%
2010	32.95%	67.05%		13.33%	86.67%
2011	26.60%	73.40%		10.76%	89.24%
2012	20.25%	79.75%		8.19%	91.81%

Table 214-14 provides the estimated weight and cost added to the average passenger car and LTV for torso bags, Table 214-15 provides the estimate for combination side air bags, Table 214-17 provides the estimates for window curtains. Side air bags provided through MY 2004 are considered voluntary and those from MY 2005 and on are considered attributable to FMVSS No. 214. Sensor costs were attributed to torso bags or combination bags for the majority of vehicles. However, there were a percentage of vehicles that had a window curtain and not a torso bag or combination bag. For these vehicles, sensor costs were attributed to window curtains. This way we assure ourselves of not counting sensor costs twice for the same vehicle. Torso bags were introduced first, and you needed a side impact sensor to trigger the bag deployment. Thus, it seemed logical to attribute sensor costs for those vehicles with torso or combination bags first and pick up the remainder of window curtains without torso bags or a combination bag in a separate calculation. Table 214-16 shows the percentage of passenger cars and LTVs that supplied window curtains without a torso bag or combination bag. These percentages were multiplied by the average weight of 2 sensors (0.29 lb) and average cost of 2 sensors ($43.20 in 2012$) plus the additional weight and cost to account for the percentage of the fleet that supplied

4 sensors and added into the window curtain average costs in Table 214-17. Table 214-18 combines all of the side air bags for the oblique pole test provided in vehicles since 1996 for passenger cars and LTVs.

Table 214-14
Average Weight (lb) and Consumer Cost (2012$) of Torso Air Bags for FMVSS No. 214 Added to Passenger Cars

Model Year	Weight (lb)			Consumer Cost (2012$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1995	0.00	0.00	0.00	$0.00	$0.00	$0.00
1996	0.03	0.00	0.03	$1.02	$0.00	$1.02
1997	0.18	0.00	0.18	$4.85	$0.00	$4.85
1998	0.57	0.00	0.57	$13.30	$0.00	$13.30
1999	0.63	0.00	0.63	$13.67	$0.00	$13.67
2000	0.98	0.00	0.98	$20.08	$0.00	$20.08
2001	1.22	0.00	1.22	$23.98	$0.00	$23.98
2002	1.28	0.00	1.28	$24.73	$0.00	$24.73
2003	1.38	0.00	1.38	$26.62	$0.00	$26.62
2004	1.51	0.00	1.51	$29.06	$0.00	$29.06
2005	1.50	0.00	1.50	$28.88	$0.00	$28.88
2006	1.51	0.69	2.20	$29.06	$13.30	$42.36
2007	1.51	1.69	3.20	$29.06	$32.57	$61.63
2008	1.51	3.01	4.52	$29.06	$58.11	$87.16
2009	1.51	4.40	5.91	$29.06	$82.36	$111.42
2010	1.51	4.78	6.29	$29.06	$89.84	$118.90
2011	1.51	5.14	6.66	$29.06	$97.07	$126.13
2012	1.51	5.59	7.10	$29.06	$105.99	$135.04

Table 214-15 Average Weight (lb) and Consumer Cost (2012$) of Combination Air Bags for FMVSS No. 214 Added to Passenger Cars						
Model Year	Weight (lb)			Consumer Cost (2012$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1995	0.00	0.00	0.00	$0.00	$0.00	$0.00
1996	0.00	0.00	0.00	$0.00	$0.00	$0.00
1997	0.00	0.00	0.00	$0.00	$0.00	$0.00
1998	0.00	0.00	0.00	$0.00	$0.00	$0.00
1999	0.18	0.00	0.18	$4.40	$0.00	$4.40
2000	0.49	0.00	0.49	$10.39	$0.00	$10.39
2001	0.70	0.00	0.70	$13.71	$0.00	$13.71
2002	0.72	0.00	0.72	$13.80	$0.00	$13.80
2003	0.63	0.00	0.63	$12.10	$0.00	$12.10
2004	0.63	0.00	0.63	$12.08	$0.00	$12.08
2005	0.63	0.15	0.78	$12.13	$2.85	$14.99
2006	0.64	0.03	0.66	$12.24	$0.57	$12.81
2007	0.53	0.00	0.53	$10.36	$0.00	$10.36
2008	0.50	0.00	0.50	$9.83	$0.00	$9.83
2009	0.51	0.00	0.51	$10.69	$0.00	$10.69
2010	0.44	0.00	0.44	$9.23	$0.00	$9.23
2011	0.41	0.00	0.41	$8.77	$0.00	$8.77
2012	0.03	0.00	0.03	$0.66	$0.00	$0.66

Table 214-16 Average Weight (lb) and Consumer Cost (2012$) of Window Curtains for FMVSS No. 214 Added to Passenger Cars						
Model Year	Weight (lb)			Consumer Cost (2012$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1995	0.00	0.00	0.00	$0.00	$0.00	$0.00
1996	0.00	0.00	0.00	$0.00	$0.00	$0.00
1997	0.00	0.00	0.00	$0.00	$0.00	$0.00
1998	0.03	0.00	0.03	$1.05	$0.00	$1.05
1999	0.08	0.00	0.08	$2.27	$0.00	$2.27
2000	0.12	0.00	0.12	$3.03	$0.00	$3.03
2001	0.46	0.00	0.46	$10.48	$0.00	$10.48
2002	0.69	0.00	0.69	$14.13	$0.00	$14.13
2003	0.93	0.00	0.93	$18.71	$0.00	$18.71
2004	1.41	0.00	1.41	$25.94	$0.00	$25.94
2005	1.39	0.21	1.60	$25.39	$3.93	$29.31
2006	1.41	2.28	3.68	$25.43	$27.56	$52.99
2007	1.41	6.22	7.63	$25.71	$59.57	$85.28
2008	1.41	8.44	9.85	$25.46	$85.26	$110.72
2009	1.41	8.35	9.75	$25.61	$99.85	$125.46
2010	1.41	8.13	9.53	$25.45	$104.48	$129.93
2011	1.41	6.11	7.52	$24.93	$103.01	$127.95
2012	1.41	6.04	7.44	$24.92	$109.74	$134.65

Table 214-17 Average Weight (lb) and Consumer Cost (2012$) of Torso Air Bags for FMVSS No. 214 Added to LTVs						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1995	0.00	0.00	0.00	$0.00	$0.00	$0.00
1996	0.00	0.00	0.00	$0.00	$0.00	$0.00
1997	0.00	0.00	0.00	$0.00	$0.00	$0.00
1998	0.14	0.00	0.14	$3.25	$0.00	$3.25
1999	0.17	0.00	0.17	$3.60	$0.00	$3.60
2000	0.41	0.00	0.41	$8.50	$0.00	$8.50
2001	0.55	0.00	0.55	$11.17	$0.00	$11.17
2002	1.18	0.00	1.18	$23.37	$0.00	$23.37
2003	0.77	0.00	0.77	$15.21	$0.00	$15.21
2004	0.95	0.00	0.95	$18.71	$0.00	$18.71
2005	0.82	0.00	0.82	$16.27	$0.00	$16.27
2006	0.95	0.20	1.15	$18.71	$4.23	$22.94
2007	0.95	0.35	1.30	$18.71	$7.61	$26.32
2008	0.95	0.91	1.85	$18.71	$19.13	$37.84
2009	0.95	2.28	3.23	$18.71	$46.12	$64.83
2010	0.95	4.03	4.98	$18.71	$80.49	$99.19
2011	0.95	4.56	5.51	$18.71	$90.32	$109.03
2012	0.95	4.59	5.54	$18.71	$90.13	$108.83

Table 214-18 Average Weight (lb) and Consumer Cost (2012$) of Combination Air Bags for FMVSS No. 214 Added to LTVs						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1995	0.00	0.00	0.00	$0.00	$0.00	$0.00
1996	0.00	0.00	0.00	$0.00	$0.00	$0.00
1997	0.00	0.00	0.00	$0.00	$0.00	$0.00
1998	0.00	0.00	0.00	$0.00	$0.00	$0.00
1999	0.08	0.00	0.08	$1.93	$0.00	$1.93
2000	0.16	0.00	0.16	$3.43	$0.00	$3.43
2001	0.47	0.00	0.47	$9.40	$0.00	$9.40
2002	0.33	0.00	0.33	$6.45	$0.00	$6.45
2003	0.33	0.00	0.33	$6.46	$0.00	$6.46
2004	0.26	0.00	0.26	$5.08	$0.00	$5.08
2005	0.18	0.00	0.18	$3.64	$0.00	$3.64
2006	0.12	0.00	0.12	$2.43	$0.00	$2.43
2007	0.08	0.00	0.08	$1.63	$0.00	$1.63
2008	0.15	0.00	0.15	$3.06	$0.00	$3.06
2009	0.08	0.00	0.08	$1.86	$0.00	$1.86
2010	0.16	0.00	0.16	$3.54	$0.00	$3.54
2011	0.16	0.00	0.16	$3.57	$0.00	$3.57
2012	0.16	0.00	0.16	$3.56	$0.00	$3.56

Table 214-19 Average Weight (lb) and Consumer Cost (2012$) of Window Curtains for FMVSS No. 214 Added to LTVs						
Model Year	Weight (lb)			Consumer Cost (2012$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1995	0.00	0.00	0.00	$0.00	$0.00	$0.00
1996	0.00	0.00	0.00	$0.00	$0.00	$0.00
1997	0.00	0.00	0.00	$0.00	$0.00	$0.00
1998	0.00	0.00	0.00	$0.00	$0.00	$0.00
1999	0.00	0.00	0.00	$0.00	$0.00	$0.00
2000	0.00	0.00	0.00	$0.09	$0.00	$0.09
2001	0.03	0.00	0.03	$0.62	$0.00	$0.62
2002	0.17	0.00	0.17	$3.45	$0.00	$3.45
2003	0.38	0.00	0.38	$6.97	$0.00	$6.97
2004	0.92	0.00	0.92	$15.02	$0.00	$15.02
2005	0.92	0.51	1.43	$14.87	$6.35	$21.22
2006	0.92	1.04	1.95	$14.71	$14.49	$29.20
2007	0.92	4.79	5.70	$15.02	$40.80	$55.82
2008	0.92	6.72	7.63	$15.02	$56.21	$71.23
2009	0.92	12.06	12.98	$15.02	$93.78	$108.80
2010	0.92	13.48	14.40	$15.02	$120.14	$135.16
2011	0.92	12.42	13.34	$15.02	$122.40	$137.42
2012	0.92	12.39	13.31	$15.02	$121.49	$136.51

Summary Tables for FMVSS No. 214

Tables 214-20 and 214-21 summarize the total weight and cost of the side impact protection systems installed in passenger cars and LTVs for MYs 1968-2012. That includes the cost of side door beams, the cost of structure and padding used to meet the TTI(d) and dynamic testing requirements, and the cost of side air bags used to meet the oblique pole test.

Table 214-20						
Average Weight (lb) and Consumer Cost (2012$) of						
All FMVSS No. 214 Countermeasures - Side Door Beams, Dynamic Testing and Side Air Bags						
Passenger Cars						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attributable**	**Total**	**Voluntary**	**Attributable**	**Total**
1968	0.00	0.00	0.00	$0.00	$0.00	$0.00
1969	6.70	0.00	6.70	$16.77	$0.00	$16.77
1970	6.64	6.98	13.62	$15.77	$16.57	$32.34
1971	6.63	9.93	16.56	$15.23	$22.80	$38.03
1972	6.67	11.99	18.67	$15.08	$27.09	$42.17
1973	6.65	25.38	32.03	$14.60	$55.77	$70.37
1974	6.22	29.06	35.29	$13.24	$61.81	$75.04
1975	5.95	27.77	33.72	$12.63	$58.96	$71.58
1976	5.64	26.31	31.94	$12.50	$58.38	$70.89
1977	5.32	24.83	30.15	$12.48	$58.26	$70.74
1978	4.99	23.30	28.29	$12.41	$57.96	$70.38
1979	4.67	21.82	26.49	$10.48	$48.92	$59.40
1980	4.66	21.75	26.41	$10.45	$48.80	$59.25
1981	4.60	21.47	26.06	$10.56	$49.29	$59.84
1982	4.57	21.33	25.90	$10.43	$48.68	$59.11
1983	4.53	21.17	25.70	$10.42	$48.64	$59.05
1984	4.54	21.18	25.72	$10.32	$48.18	$58.49
1985	4.52	21.08	25.60	$10.28	$47.99	$58.27
1986	4.51	21.04	25.55	$10.21	$47.68	$57.90
1987	4.49	20.96	25.44	$10.18	$47.54	$57.72
1988	4.51	21.05	25.56	$10.07	$47.02	$57.09
1989	4.51	21.07	25.59	$10.01	$46.71	$56.72
1990	4.47	20.89	25.36	$10.04	$46.86	$56.89
1991	4.46	20.85	25.31	$10.01	$46.73	$56.74
1992	4.44	20.71	25.14	$10.02	$46.80	$56.83
1993	4.44	20.73	25.17	$9.97	$46.55	$56.52
1994	4.44	27.32	31.76	$9.91	$81.20	$91.10
1995	4.42	35.71	40.13	$9.87	$116.44	$126.31
1996	4.44	44.31	48.74	$10.87	$148.35	$159.22
1997	4.57	57.56	62.13	$14.67	$195.79	$210.46
1998	4.98	57.79	62.77	$24.15	$190.75	$214.90
1999	5.27	57.77	63.04	$30.07	$186.28	$216.36
2000	5.95	57.85	63.80	$43.19	$183.04	$226.22

2001	6.74	57.89	64.63	$57.81	$180.47	$238.29
2002	7.04	58.00	65.05	$62.27	$178.58	$240.85
2003	7.29	58.21	65.50	$67.02	$177.33	$244.36
2004	7.91	58.06	65.97	$76.61	$175.26	$251.87
2005	7.86	58.75	66.60	$75.93	$181.46	$257.39
2006	7.90	61.29	69.18	$76.21	$214.49	$290.70
2007	7.79	66.30	74.08	$74.59	$264.21	$338.80
2008	7.76	69.81	77.57	$73.77	$314.34	$388.11
2009	7.77	71.09	78.86	$74.76	$352.38	$427.14
2010	7.69	71.38	79.07	$73.12	$364.09	$437.21
2011	7.64	70.04	77.68	$72.17	$369.90	$442.07
2012	7.27	70.24	77.51	$63.98	$384.20	$448.18

Table 214-21						
Average Weight (lb) and Consumer Cost (2012$) of						
All FMVSS No. 214 Countermeasures - Side Door Beams, Dynamic Testing and Side Air Bags						
LTVs						
Model Year	Weight (lb)			Consumer Cost (2012$)		
	Voluntary	Attributable	Total	Voluntary	Attributable	Total
1990	0.00	0.00	0.00	$0.00	$0.00	$0.00
1991	0.00	1.72	1.72	$0.00	$2.11	$2.11
1992	0.00	1.91	1.91	$0.00	$2.33	$2.33
1993	0.00	2.83	2.83	$0.00	$3.45	$3.45
1994	0.00	15.00	15.00	$0.00	$18.15	$18.15
1995	0.00	15.00	15.00	$0.00	$18.03	$18.03
1996	0.00	15.00	15.00	$0.00	$17.92	$17.92
1997	0.00	15.00	15.00	$0.00	$17.82	$17.82
1998	0.14	15.00	15.14	$3.25	$17.72	$20.97
1999	0.25	15.00	15.25	$5.53	$17.61	$23.14
2000	0.57	15.00	15.57	$12.02	$17.51	$29.53
2001	1.04	15.00	16.04	$21.18	$17.42	$38.60
2002	1.67	15.00	16.67	$33.27	$17.33	$50.60
2003	1.48	15.00	16.48	$28.65	$17.25	$45.90
2004	2.12	15.00	17.12	$38.81	$17.17	$55.98
2005	1.92	15.51	17.44	$34.77	$23.45	$58.23
2006	1.98	16.24	18.22	$35.85	$35.75	$71.60
2007	1.94	20.14	22.09	$35.35	$65.37	$100.73
2008	2.01	22.62	24.63	$36.78	$92.25	$129.03
2009	1.95	29.34	31.29	$35.58	$156.77	$192.36
2010	2.02	32.51	34.53	$37.27	$217.46	$254.73
2011	2.02	31.98	34.01	$37.30	$229.50	$266.80
2012	2.02	31.98	34.00	$37.28	$228.35	$265.64

FMVSS No. 215 – [Does not currently exist]

FMVSS No. 216, Roof crush resistance

Initial Standard

FMVSS No. 216 went into effect on September 1, 1973, (passenger cars) and September 1, 1993, (multipurpose passenger vehicles, trucks, and buses) and established strength requirements for the passenger compartment roof. The purpose of this standard is to reduce deaths and injuries due to the crushing of the roof into the occupant compartment in rollover crashes. The original standard applied to passenger cars, multipurpose passenger vehicles, trucks, and buses with a

GVWR of 6,000 pounds or less. It did not apply to school buses, vehicles that conform to the rollover test requirements of FMVSS No. 208 by means that require no action by vehicle occupants, and convertibles (except for optional compliance with the standard as an alternative to the rollover test requirements of FMVSS No. 208). FMVSS No. 216 is a performance standard limiting the amount of crush allowed when a load is gradually applied to the roof of a vehicle.

In October 1967, almost six years before the eventual effective date of FMVSS No. 216, NHTSA issued an ANPRM broaching possible limits on the intrusion of a vehicle's roof, front, side and rear structures into the passenger compartment during crashes. The roof intrusion portion of the ANPRM was a starting point for FMVSS No. 216. The industry developed a procedure for measuring static roof crush resistance, SAE Recommended Practice J374, dated December 1968, without defining specific pass-fail levels. Soon after, the new generation of hardtops with more vulnerable roof structures spurred NHTSA to issue FMVSS No. 216, with an NPRM in January 1971, a final rule on December 8, 1971, (36 FR 23299) and an effective date of September 1, 1973, establishing FMVSS No. 216 for passenger cars. The NPRM was published in the Federal Register on January 6, 1971, (36 FR 166) making the baseline date for passenger cars September 1, 1970, or MY 1971. The FMVSS largely incorporates the J374 procedure and sets a 5-inch limit on crush given a load of 1½ times the unloaded vehicle weight, but no more than 5,000 pounds if the vehicle is a passenger car, applied to one of the sides of the roof, at the forward edge.[183]

A rather simple quasi-static test (where the load is gradually applied) was preferred to a staged rollover crash because there was no repeatable, standardized rollover test that would have worked for all make-models. However, the application of the load in the static test to the front and side of the roof resembles many rollover crashes. A vehicle is required to support 1½ times its weight, rather than just its own weight, because rollovers involve an additional dynamic load when the vehicle flips onto its roof. However, passenger cars weighing over 3,333 pounds need only support a 5,000 pound load, less than 1½ times their weight and are essentially held to a less strict FMVSS No. 216 requirement, since they are generally less rollover-prone than LTVs and lighter passenger cars.

Most passenger cars built since September 1, 1973, have easily complied with FMVSS No. 216, and it is also believed most cars built before that date could have met the standard.[184] However, NHTSA does not have detailed information on pass/fail rates for the baseline MY 1971 vehicles. It was primarily full-sized hardtops of the late 1960s and early 1970s that had typically borderline or worse performance. This body style was phased out (redesigned as a pillared hardtop or sedan) a few years before or after FMVSS No. 216 took effect. Although some true hardtops were built after 1973 and did meet FMVSS No. 216, they were pretty much gone by the late 1970s. These changes did not have any direct cost because it was cheaper to build a sedan than a hardtop. However, there is an indirect cost of lost sales. Hardtops were attractive for sales, which meant higher prices. Unfortunately, these intangible costs cannot be determined by cost teardown analysis.

[183] Kahane, 1989; *Federal Register* 32 (October 13, 1967): 14278, 36 (January 6, 1971): 166, 36 (December 8, 1971): 23299; SAE. (1973). *1973 SAE Handbook*. New York: Society of Automotive Engineers.
[184] Kahane, DOT HS 807 489, 1989).

Whereas the phasing out of true hardtops was the most visible design change, it appears that pillars or roof structure were strengthened, without major redesign, in many vehicles. A study was conducted in 1982 to determine the implementation consumer price and weight variance of FMVSS No. 216 in 1974 model year vehicles compared to the 1973 model year vehicles.[185] Twenty-four passenger cars from 1974, along with comparable 1973 make-models, were reviewed. The changes were analyzed upward from the belt line and included a review of the A, B, and C pillars and the roof structure. From this study, we singled out twenty-one make-models that did not receive any overall vehicle redesign in 1974. For these make-models, it is plausible that any change from 1973 to 1974 is specifically due to FMVSS No. 216 and it is attributable to the standard since it was after the baseline on MY 1971. Table 216-1 shows the estimated increase in weight and consumer cost of roof crush attributable to FMVSS No. 216 in passenger cars before considering the learning curve.

TABLE 216-1
AVERAGE WEIGHT AND CONSUMER COST
OF ROOF CRUSH INITIAL STANDARD
FMVSS No. 216
IN PASSENGER CARS

MODEL YEAR	WEIGHT IN POUNDS	CONSUMER COST ($2012)
1974-2012	2.93	$4.28

NHTSA believes that LTVs met the initial FMVSS No. 216 well before the effective date of September 1, 1993, and well before the baseline of MY 1990, with no substantial changes in roof design around that time. The final rule extending FMVSS No. 216 to LTVs with GVWR of 6,000 pounds or less was published in the Federal Register on April 17, 1991, (56 FR 15510). The NPRM was published on November 2, 1989, (54 FR 46275) making the baseline September 1, 1989, or MY 1990. Consequently, no cost studies of roof crush in LTVs have been performed, and none are planned by NHTSA.

Upgraded Standard

On May 12, 2009, (74 FR 22347) NHTSA published in the Federal Register a final rule upgrading FMVSS No. 216, Roof crush resistance for passenger cars and LTVs of 10,000 pounds GVWR or less. The NPRM was issued on August 25, 2005, (70 FR 49223) making the baseline date September 1, 2004, or MY 2005. NHTSA upgraded FMVSS No. 216 in several ways; the upgraded standard is called FMVSS No. 216a. First, before the upgrade, the standard applied only to vehicles up to 6,000 pounds GVWR and the test involved loading the roof with 1½ times the vehicle's unloaded vehicle weight (and no more than 5,000 pounds if the vehicle is a passenger car). The upgrade extends the standard to vehicles up to 10,000 pounds GVWR; test weight is 3 times the unloaded vehicle weight for vehicles under 6,000 pounds GVWR; it is 1½ times the unloaded vehicle weight for vehicles from 6,000 to 10,000 pounds GVWR. The effective dates of phase-in for the upgraded standard for first part of the rule are:

[185] Gladstone, Harvey, Lesczhik, & McLean, DOT HS 806 769, 1982), Docket No. 2011-0066-0013.

- 20 percent of vehicles manufactured on or after September 1, 2012, and before September 1, 2013, must comply.
- 50 percent of vehicles manufactured on or after September 1, 2013, and before September 1, 2014, must comply.
- 75 percent of vehicles manufactured on or after September 1, 2014, and before September 1, 2015, must comply.
- 100 percent of vehicles manufactured on or after September 1, 2015, must comply.

There are special provisions relating to lead time for multi-stage manufacturers, alterers, and small volume manufacturers.

Second, vehicles must meet the force requirement in a two-sided test. The same vehicle must meet the force requirements when tested on one-side of the vehicle and then on the other side of the vehicle.

Third, the rule establishes a new requirement for maintenance of headroom, i.e., survival space, during testing in addition to the existing limit on roof crush (5 inches) during the test.

Weight and cost estimates were taken from the Final Regulatory Impact Analysis[186] that accompanied the final rule. NHTSA estimated weights and costs in the FRIA based on a variety of information, including modeling, contractor and supplier information, as well as comments to the NPRM docket. After the rule has been in effect for a few years, NHTSA plans to estimate costs with a teardown study.

The estimated failure rate for those vehicles under 6,000 pounds GVWR with the final rule strength to weight ratio of 3.0 was 82 percent. An examination of the MY 2004 to MY 2008 testing shows no obvious difference between passenger cars and LTVs in the strength to weight ratio, for those vehicles under 6,000 pounds GVWR. Thus, this estimate applied to both passenger cars and LTVs.

On a model year basis, the first year of the phase-in (MY 2013) is outside the scope of this analysis. However, there is attributable compliance which is within the scope of the analysis and will be estimated here. NHTSA has compliance data provided by the manufacturers for MY 2011 and MY 2012. In this case, manufacturer's certification of compliance is supplied voluntarily, since the upgraded standard did not apply yet to these model years. However, because the manufacturer's compliance data is supplied voluntarily, it may not be as complete as if compliance data reporting were required. For example, one manufacturer only certified compliance with two make-models for MY 2011 and four make-models for MY 2012 (yet NHTSA tested five MY 2004-2008 make-models that passed). This could mean that manufacturer has not yet tested these vehicles to the upgraded FMVSS No. 216a test and is not willing to use the NHTSA test results from older make-models to certify compliance. Thus, we suspect that the certified compliance rates will be low compared to true voluntary compliance. The certified compliance rates for MY 2011 were 9.8 percent for passenger cars and 13.0 percent for LTVs under 6,000 pounds GVWR. Both of these rates were below the voluntary compliance

[186] NHTSA, *Final Regulatory Impact Analysis, FMVSS 216, Upgrade Roof Crush Resistance,* April 2009, Docket No.2009-0093-0004.

rate we found from MY 2004 to MY 2008 testing of 17.96 percent for both. For MY 2012 the certified compliance rates supplied by the manufacturers were 25.47 percent for passenger cars and 11.5 percent for LTVs under 6,000 pounds GVWR. Since the certified compliance is greater for MY 2012 than the MY 2004 to MY 2008 test results for passenger cars, we will use the difference between the 25.47 percent and the 17.96 percent (or 7.51%) as attributable to meeting the upgraded standard for passenger cars for MY 2012. Since the certified compliance rate for LTVs under 6,000 pounds went down from MY 2011 to MY 2012, we assume no increase in weight and costs for FMVSS No. 216a for LTVs under 6,000 pounds GVWR for MY 2012. Thus, Table 216-4 for LTVs shows no weight and cost impact.

For this analysis we have not assumed that manufacturers that meet the upgraded test requirements of FMVSS No. 216a earlier than the phase-in requirements have voluntarily spent money on safety before the requirements. There is no evidence that manufacturers changed anything in their vehicles roof structure as a result of upcoming FMVSS 216a requirements. Thus, we are not assuming voluntary compliance with a standard. It appears likely that these vehicles' designs were just stronger to begin with.

NHTSA believes manufacturers will meet the upgraded FMVSS No. 216 by strengthening reinforcements in roof pillars, by increasing the gauge in steel used in roofs, or by using higher strength materials.

The weight and cost impacts are very complex and depend upon whether a manufacturer chooses to use high strength steel or aluminum or other materials which are lighter and stronger. Given that we are only looking at attributable costs up through the 2012 model year in this analysis, we have chosen to assume that the more commonly used current materials of high strength steel or aluminum would be implemented. Table 216-2 provides the estimated incremental weight and consumer cost for passenger cars and LTVs. Since we are only applying attributable costs to MY 2012, there is no need to apply the learning curve for later model years.

TABLE 216-2
AVERAGE WEIGHT AND CONSUMER COST
OF ROOF CRUSH UPGRADED STANDARD – FMVSS No. 216a
IN PASSENGER CARS AND LTVS

	WEIGHT IN POUNDS	**CONSUMER COST ($2012)**
Passenger Cars	18.8	$51.83
LTVs < 6,000 lb. GVWR	18.8	$51.83
LTVs from 6,000 to 10,000 lb. GVWR	12.5	$74.46

Table 216-3 for passenger cars provides the combined estimated weight and consumer cost impacts for the initial and upgraded FMVSS 216 standard. Only MY 2012 includes values for the upgraded standard for passenger cars. For the upgraded standard FMVSS No. 216a for passenger cars in Table 216-3, the incremental percent of the fleet certified to pass the standard in MY 2012 of 7.51 percent is multiplied by the weight impact of 18.8 pounds (18.8 * .0751 = 1.41 pounds) and the cost impact of $51.83 ($51.83 * .0751 = $3.89).

Table 216-3
Average Weight (lb) and Consumer Cost (2012$) of
FMVSS No. 216 Roof Crush Resistance
Initial and Upgraded Standard
Passenger Cars

Model Year	Weight (lb)			Consumer Cost (2012$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
1968	0	0	0	$0.00	$0.00	$0.00
1969	0	0	0	$0.00	$0.00	$0.00
1970	0	0	0	$0.00	$0.00	$0.00
1971	0	0	0	$0.00	$0.00	$0.00
1972	0	0	0	$0.00	$0.00	$0.00
1973	0	0	0	$0.00	$0.00	$0.00
1974	0	2.93	2.93	$0.00	$4.28	$4.28
1975	0	2.93	2.93	$0.00	$3.99	$3.99
1976	0	2.93	2.93	$0.00	$3.80	$3.80
1977	0	2.93	2.93	$0.00	$3.67	$3.67
1978	0	2.93	2.93	$0.00	$3.57	$3.57
1979	0	2.93	2.93	$0.00	$3.50	$3.50
1980	0	2.93	2.93	$0.00	$3.45	$3.45
1981	0	2.93	2.93	$0.00	$3.41	$3.41
1982	0	2.93	2.93	$0.00	$3.38	$3.38
1983	0	2.93	2.93	$0.00	$3.34	$3.34
1984	0	2.93	2.93	$0.00	$3.30	$3.30
1985	0	2.93	2.93	$0.00	$3.27	$3.27
1986	0	2.93	2.93	$0.00	$3.24	$3.24
1987	0	2.93	2.93	$0.00	$3.21	$3.21
1988	0	2.93	2.93	$0.00	$3.19	$3.19
1989	0	2.93	2.93	$0.00	$3.17	$3.17
1990	0	2.93	2.93	$0.00	$3.15	$3.15
1991	0	2.93	2.93	$0.00	$3.13	$3.13
1992	0	2.93	2.93	$0.00	$3.12	$3.12
1993	0	2.93	2.93	$0.00	$3.10	$3.10
1994	0	2.93	2.93	$0.00	$3.09	$3.09
1995	0	2.93	2.93	$0.00	$3.07	$3.07
1996	0	2.93	2.93	$0.00	$3.06	$3.06
1997	0	2.93	2.93	$0.00	$3.05	$3.05

1998	0	2.93	2.93	$0.00	$3.04	$3.04
1999	0	2.93	2.93	$0.00	$3.03	$3.03
2000	0	2.93	2.93	$0.00	$3.02	$3.02
2001	0	2.93	2.93	$0.00	$3.01	$3.01
2002	0	2.93	2.93	$0.00	$3.00	$3.00
2003	0	2.93	2.93	$0.00	$2.99	$2.99
2004	0	2.93	2.93	$0.00	$2.98	$2.98
2005	0	2.93	2.93	$0.00	$2.97	$2.97
2006	0	2.93	2.93	$0.00	$2.96	$2.96
2007	0	2.93	2.93	$0.00	$2.95	$2.95
2008	0	2.93	2.93	$0.00	$2.95	$2.95
2009	0	2.93	2.93	$0.00	$2.94	$2.94
2010	0	2.93	2.93	$0.00	$2.94	$2.94
2011	0	2.93	2.93	$0.00	$2.93	$2.93
2012	0	4.34	4.34	$0.00	$6.82	$6.82

Table 216-4
FMVSS No. 216 Combined Initial and Upgraded Standards
LTVs by Model Year
Weight (lb) and Consumer Costs (2012$)

Model Year	Initial Standard		Upgraded Standard		Combined	
	Weight	Consumer Cost	Weight	Consumer Cost	Weight	Consumer Cost
2012	0.00	$0.00	0.00	$0.00	0.00	$0.00

FMVSS No. 217, Bus emergency exits and window retention and release

FMVSS No. 217 took effect on September 1, 1973, and establishes minimum requirements for bus window retention and release to reduce the likelihood of passenger ejection in crashes and for emergency exits to facilitate passenger exit in emergencies. Since this standard does not regulate components of new passenger cars or LTVs, it is outside the scope of this report. No cost studies of this standard have been done.

FMVSS No. 218, Motorcycle helmets

FMVSS No. 218 took effect on March 1, 1974, 1974, and establishes minimum performance requirements for helmets designed for use by motorcyclists and other motor vehicle users to reduce deaths and injuries resulting from head impacts. Since this standard does not regulate components of new passenger cars or LTVs, it is outside the scope of this report. Some cost estimates have been made regarding motorcycle helmets. See Docket No. 2011-0050-0002, Appendix B.

FMVSS No. 219, Windshield zone intrusion

FMVSS No. 219 took effect on September 1, 1976, (passenger cars) and September 1, 1977, (multipurpose passenger vehicles, trucks, and buses) and specifies limits for the displacement into the windshield area of motor vehicle components during a crash. The purpose of this standard is to reduce crash injuries and fatalities that result from occupants contacting vehicle components displaced near or through the windshield. This standard applies to passenger cars and to multipurpose passenger vehicles, trucks, and buses with a GVWR of 10,000 pounds or less. However, it does not apply to forward control vehicles, walk-in van-type vehicles or to body-type vehicles with fold-down or removable windshields. The final rule was published in the Federal Register on June 16, 1975, (40 FR 25462) for passenger cars and LTVs. Two NPRMs were published in the Federal Register on FMVSS No. 219 on August 31, 1972, (37 FR 17763) and May 20, 1974, (39 FR 17768) making the baseline date September 1, 1971, or MY 1972.

A study was conducted in 1982 on twelve make-model pre-standard (1976) passenger cars, and their corresponding implementation (1977) and post-standard (1978) systems.[187] From that study, we singled out ten make-models that did not receive an overall vehicle redesign in 1977. Those ten make-models had no changes in weight and cost from 1976 to 1978. Because our teardowns did not show any added weight or cost in the standards implementation year, we will not attribute any weight or cost to FMVSS No. 219. However, it is conceivable that a more thorough teardown study including vehicles from the baseline year of MY 1972 could have revealed costs of changes made in anticipation of FMVSS No. 219, if there were any.

NHTSA has no data indicating that the hood crumple features related to FMVSS No. 219 (for example, a pre-crimp in the hood sheet metal or hinge changes to keep the hood from intruding into the windshield) resulted in direct variable cost and weight additions to the vehicles. There were certainly some sort of research and development and tooling costs associated with this change at some point. However, NHTSA has no estimate of the R&D and tooling costs. NHTSAs estimate of indirect costs is linked to the absolute value of direct variable cost changes. Regardless of whether these costs occurred before or after the NPRM and would be counted in this analysis, if we don’t have a direct cost estimate for the change, we don’t have a basis for estimating indirect costs. NHTSA has no plans to do further analysis into FMVSS No. 219.

FMVSS No. 220, School bus rollover protection

FMVSS No. 220 took effect on April 1, 1977, and establishes performance requirements for school bus rollover protection to reduce the number of deaths and the severity of injuries that result from failure of the school bus body structure to withstand forces encountered in rollover crashes. A cost study was completed in 1979.[188] Since this standard does not regulate components of new passenger cars or LTVs, it is outside the scope of this report.

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[187] McVetty, Cross, & Parr, DOT HS 806 187,1982), Docket No. 2011-0066-0068.

[188] Harvey, M. R., Lesczhik, J. A., & McLean, R. F. (1979, November). Cost evaluation for nine Federal Motor Vehicle Standards, Vol. VI, FMVSS 221, 220, & 222 (Report No DOT HS 805 320), Docket No.2011-0066-0073. Washington, DC: National Highway Traffic Safety Administration. Available at http://ntl.bts.gov/lib/57000/57300/57334/costevaluationfo00harv.pdf

FMVSS No. 221, School bus body joint strength

FMVSS No. 221 took effect on April 1, 1977, and establishes requirements for the strength of the body panel joints in school bus bodies to reduce deaths and injuries resulting from the structural collapse of school bus bodies during crashes. A cost study was completed in 1979.[189] Since this standard does not regulate components of new passenger cars or LTVs, it is outside the scope of this report.

FMVSS No. 222, School bus passenger seating and crash protection

FMVSS No. 222 took effect on April 1, 1977, and establishes occupant protection requirements for school bus passenger seating and restraining barriers to reduce the number of deaths and the severity of injuries that result from the impact of school bus occupants against structures within the vehicle during crashes and sudden driving maneuvers. A cost study was completed in 1979.[190] Since this standard does not regulate components of new passenger cars or LTVs, it is outside the scope of this report.

FMVSS No. 223, Rear impact guards

FMVSS No. 223 took effect on January 26, 1998, and specifies requirements for rear impact guards for trailers and semi-trailers to reduce the number of deaths and serious injuries that occur when light duty vehicles collide with the rear end of trailers and semi-trailers. Since this standard does not regulate components of new passenger cars or LTVs, it is outside the scope of this report.

FMVSS No. 224, Rear impact protection

FMVSS No. 224 took effect on January 26, 1998, and establishes requirements for the installation of rear impact guards on trailers and semi-trailers with a GVWR of 10,000 pounds or more to reduce the number of deaths and serious injuries occurring when light duty vehicles impact the rear of trailers and semi-trailers of 10,000 pounds or more. Since this standard does not regulate components of new passenger cars or LTVs, it is outside the scope of this report.

FMVSS No. 225, Child restraint anchorage systems

FMVSS No. 225 establishes requirements for child restraint anchorage systems to ensure their proper location and strength for the effective securing of child restraints, to reduce the likelihood of the anchorage systems' failure, and to increase the likelihood that child restraints are properly secured and thus more fully achieve their potential effectiveness in motor vehicles. This standard applies to passenger cars; to trucks and multipurpose passenger vehicles with a GVWR of 8,500 pounds or less, except walk-in van-type vehicles and vehicles manufactured to be sold exclusively to the U.S. Postal Service; and to buses (including school buses) with a GVWR of 10,000 pounds or less, except shuttle buses. The LATCH system (Lower Anchorages and Tethers for CHildren) does not use the seat belts in the vehicle to secure child restraints, but uses

[189] Ibid.
[190] Ibid.

horizontal bars (lower anchorages) that are secured in the vehicle seat bight (between the seat cushion and seat back) and tether anchorages (a tether strap that is connected to tether anchorage hardware that can be positioned in various places) for upper child restraint support of forward facing seats.

The final rule establishing FMVSS No. 225 for passenger cars and LTVs and amending FMVSS No. 213 to require upper and lower tethers on child safety seats was published in the Federal Register on March 5, 1999, (64 FR 10786). The NPRM was published in the Federal Register on February 20, 1997, (62 FR 7858) making the baseline date September 1, 1996, or MY 1997. There were no vehicles with LATCH by the baseline date of MY 1997, thus all weights and costs are attributable to the standard. There may have been some vehicles with upper tethers available before MY 2000, but NHTSA has no data on what percentage were supplied by model year.

Percentage of fleet required - On forward-facing child safety seats (with a few exceptions), testing with upper tethers with reduced excursion requirements took effect on September 1, 1999, and testing with installation using lower attachments took effect on September 1, 2002. In passenger cars, an 80-percent phase-in, excluding convertibles, of upper tether anchorages extended from September 1, 1999, to September 1, 2000, and then 100 percent of passenger cars and LTVs of 8,500 GVWR or less were required to comply starting September 1, 2000. Lower anchorages phase in for passenger cars and LTVs of 8,500 GVWR or less required 20 percent from September 1, 2000, to September 1, 2001, 50 percent compliance from September 1, 2001, to September 1, 2002, and then 100 percent compliance starting September 1, 2002.

Data to determine what percent of the fleet was installed with upper tethers and lower anchors is not easy to find. NHTSA's Office of Compliance did not ask manufacturers to supply certification data for MY 2000 to MY 2002 during the phase-in, but surely manufacturers met the required use of upper tethers and lower anchors during the phase-in. For this analysis we are going to assume that manufacturer exactly met the requirements, even though it is likely that they exceeded the percentage requirements. Table 225-1 shows the percentage of the fleet required for passenger cars and LTVs by model year.

Table 225-1				
Percentage of Fleet Required to Meet FMVSS 225				
Passenger Cars and LTVs				
	Passenger Cars		LTVs	
Model Year	Upper Tethers	Lower Anchors	Upper Tethers	Lower Anchors
1999	0	0	0	0
2000	80	0	0	0
2001	100	20	100	20
2002	100	50	100	50
2003	100	100	100	100
2004	100	100	100	100
2005	100	100	100	100
2006	100	100	100	100
2007	100	100	100	100
2008	100	100	100	100
2009	100	100	100	100
2010	100	100	100	100
2011	100	100	100	100
2012	100	100	100	100

Number of seating positions covered - A vehicle with three or more designated forward-facing rear seating positions is required to have tether anchorages in at least three of those positions and lower anchorages in at least two of those positions. The parts of the system include a lower anchorage for both sides (inboard and outboard) of a designated seating position, a tether anchor, a cover for the tether anchor, and a button or some other marking for the lower anchors (four buttons or markings for two seating positions).

According to FMVSS No. 225, a vehicle with only two rear seating positions would have two sets of lower anchors and two tether anchors, and a vehicle with three or more seating rear seating positions must have two sets of lower anchors and three tether anchors. A vehicle with no rear seating positions must have lower anchors and a tether for the front right seat. Vehicles with two sets of rear seats (a second and third row of seats) might have anchors in both sets of rear seats, thus letting parents decide where they would rather seat their children. The lower anchors are located between the seat back and the seat bottom cushion (within the seat bight). Most passenger cars would have the top tether on the rear seat package shelf with a cover over the anchorage to hide it. However, the tether anchor can be located in other places. For example, with minivans the tether anchor for the second row of seats is typically located on the back bottom of the seat, without any type of cover and the tether anchor could be located on the roof or any strong structure to the rear of the seating position.

To determine the percentage of the fleet that was supplied with LATCH equipment, data was taken from a study of 98 vehicles[191] with LATCH, 88 were MY 2011 vehicles and 10 were MY 2010 vehicles. The findings were that in the second row, only 7 of 98 vehicles provided 3 lower anchors and 3 tethers, while the other 91 vehicles provided the required 2 lower anchors positions and 3 tethers. Of the 21 SUVs or minivans that had a third row, 11 had no lower anchors, 2 had two lower anchor positions and 8 had 1 lower anchor position. For the third row tether, 4 had no tethers and 15 had 1 tether position and 2 vehicles had 3 tethers.

A similar analysis to determine the percentage of the fleet supplied with LATCH equipment was undertaken using *Buying a Safer Car for Child Passengers, 2010.*[192] This study tells what seating positions are equipped with lower anchors by make-model. This data was weighted by Polk registration data by make model. We estimated the number of upper anchors per vehicle, based on the following rationale: 0 if no rear seat or no lower anchors; 2 if the rear seat had only 2 designated seating positions; 3 if the rear seats have 3 or more designated seating positions, but the vehicle has only 2 seating positions with lower anchors; 4 or more if there are 4 or more seats with lower anchors (and if the second and third row each have 3 seating positions and the 2 outboard seats in each row have lower anchors we assume all 6 positions have the upper anchors). These two data sets resulted in essentially the same data (see Table 225-2). We decided to use the UMTRI data since it was a little more exact on the upper anchorages. While we did not have data on the number of voluntarily supplied LATCH for the third seat similar to the UMTRI study on earlier model years (earlier than MY 2010) we assumed the same distribution for previous years back to the effective date of MY 2000. Even in MY 2010/11 most of the vehicles only provided the required number of anchorages.

Table 225-2
Average Number of Lower Anchors
And Upper Tether Anchors per Vehicle

		Passenger Cars		**LTVs**	
Model Year		**Lower Anchors**	**Upper Tether Anchors**	**Lower Anchors**	**Upper Tether Anchors**
2011	UMTRI data	2.09	2.97	2.12	2.86
2010	Buying a Safer Car	2.12	2.91	2.04	2.79

[191] Klinich, K. D., Flannagan, C. A.C., Manary, M. A., and Moore, J. L. (2012, April). *LATCH Usability in Vehicles* (Report No. UMTRI 2012-7). Ann Arbor, MI: University of Michigan Transportation Research Institute. Available at http://deepblue.lib.umich.edu/handle/2027.42/90856

[192] NHTSA¨ (2010, July). *Buying a Safer Car for Child Passengers, 2010, a Guide for Parents* (Report No. DOT HS 811 360) Washington, DC: National Highway Traffic Safety Administration.

Weight and Cost Estimates - Using data from a cost study[193] of this standard we found the average cost of lower anchors and upper tether anchors by averaging the results from 6 vehicles – a MY 2013 Ford Fusion, a MY 2011 VW Passat, a MY 2013 Hyundai Elantra, a MY 2014 Honda Odyssey, a MY 2012 Chevrolet Equinox, and a MY 2012 Ford F-250 Supercab. Based on this data, there appears to be no difference in cost between passenger cars and LTVs, thus we will use the same cost estimates for both. It appears best to provide the data on a row by row basis, rather than on a seating position basis because some rows have 2 lower anchors and 2 tether anchor positions and other rows have 2 lower anchors and 3 tether anchor positions. Table 225-3 presents these results averaged over the 6 vehicles. Each of these 6 vehicles had one row with 2 lower anchors and 3 tether anchors (the Honda Odyssey in the third row). Only the Honda Odyssey had a second row with 2 lower anchors and 2 tether anchors; however we estimated the weight and cost impacts for the other vehicles based on the detailed information of the weight and cost of lower anchors and tether anchors from each vehicle. For a vehicle with no rear seat, we take one-half of the 2 lower anchors and one-half of the 2 tether anchors and assume they apply to the front right seat.

Based on the data from the UMTRI studies and the cost teardown, estimates were made of the percentage of the fleet that were equipped with LATCH at the various seating positions and the weight and cost impacts by the number of lower anchorages and upper tether anchorages provided. Table 225-3 provides the basic data used to determine the average weight and cost. In Table 225-3, the third seat weight and cost include the assumption that the second seat provides 2 lower anchors and 2 tethers.

[193] Ricardo Inc. (2014, May 30). *Cost and weight analysis for LATCH equipment for child safety seats and vehicles* (Report submitted in response to NHTSA Solicitation Number: DTNH22-10-D-00197/0003, and found in Docket No. 2011-0066-0088). Van Buren Twp., MI.

Table 225-3						
Estimated Weight and Cost (2012$)						
For Lower Anchors and Tether Anchors - FMVSS No. 225						
Average for Passenger Cars and LTVs						
	Passenger Cars			**LTVs**		
Right Front Seat	**% of fleet**	**Weight**	**Cost**	**% of fleet**	**Weight**	**Cost**
0 lower + 0 tether				7.6	0	0
1 lower + 1 tether	0.8	0.70	$2.35			
Second Seat Only						
2 lower + 2 tether	0.9	1.39	$4.69	7.0	1.39	$4.69
2 lower + 3 tether	88.0	1.61	$5.45	50.6	1.61	$5.45
3 lower + 3 tether	10.3	2.12	$7.16	5.2	2.12	$7.16
Third Seat						
0 lower + 1 tether				13.9	1.58	$5.32
1 lower + 1 tether				12.2	1.39	$4.69
2 lower + 3 tether				3.5	3.00	$10.14
Weighted Average	100	1.65	$5.59	100	1.51	$5.11
Average per						
Seat Position						
Lower Anchors		0.51	$1.71		0.51	$1.71
Tether Anchors		0.20	$0.67		0.20	$0.67

Table 225-4 and Table 225-5 present the average weight and consumer cost for passenger cars and LTVs respectively after applying the learning curve. These estimates take into account the percentage of the fleet which are required to meet the standard and the number of seating positions that were equipped with lower anchors and tether anchors.

Table 225-4 Average Weight (lb) and Consumer Cost (2012$) of FMVSS No. 225 Lower Anchors and Tether Anchors Passenger Cars						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1999	0	0.00	0.00	0	$0.00	$0.00
2000	0	0.47	0.47	0	$1.60	$1.60
2001	0	0.80	0.80	0	$4.06	$4.06
2002	0	1.12	1.12	0	$4.98	$4.98
2003	0	1.65	1.65	0	$6.69	$6.69
2004	0	1.65	1.65	0	$6.37	$6.37
2005	0	1.65	1.65	0	$6.16	$6.16
2006	0	1.65	1.65	0	$6.01	$6.01
2007	0	1.65	1.65	0	$5.90	$5.90
2008	0	1.65	1.65	0	$5.82	$5.82
2009	0	1.65	1.65	0	$5.76	$5.76
2010	0	1.65	1.65	0	$5.71	$5.71
2011	0	1.65	1.65	0	$5.65	$5.65
2012	0	1.65	1.65	0	$5.59	$5.59

Table 225-5 Average Weight (lb) and Consumer Cost (2012$) of FMVSS No. 225 Lower Anchors and Tether Anchors LTVs						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1999	0	0.00	0.00	0	$0.00	$0.00
2000	0	0.00	0.00	0	$0.00	$0.00
2001	0	0.72	0.72	0	$3.66	$3.66
2002	0	1.02	1.02	0	$4.54	$4.54
2003	0	1.52	1.52	0	$6.11	$6.11
2004	0	1.52	1.52	0	$5.82	$5.82
2005	0	1.52	1.52	0	$5.63	$5.63
2006	0	1.52	1.52	0	$5.50	$5.50
2007	0	1.52	1.52	0	$5.39	$5.39
2008	0	1.52	1.52	0	$5.32	$5.32
2009	0	1.52	1.52	0	$5.27	$5.27
2010	0	1.52	1.52	0	$5.22	$5.22
2011	0	1.52	1.52	0	$5.17	$5.17
2012	0	1.52	1.52	0	$5.11	$5.11

FMVSS No. 226, Ejection mitigation

The goal of FMVSS No. 226 is to prevent ejection of unrestrained occupants and to prevent the partial ejection of belted occupants through side windows in rollovers and other crashes. On January 19, 2011, (76 FR 3212) NHTSA published in the Federal Register the final rule for passenger cars and LTVs. The NPRM was published in the Federal Register on December 2, 2009, (74 FR 63180) making the baseline date September 1, 2009, or MY 2010. The standard applies to passenger cars and LTVs with GVWR of 10,000 pounds or less, except convertibles and some other vehicles. The phase-in period includes:

- 25 percent of new vehicles produced from September 1, 2013, to August 31, 2014;
- 50 percent from September 1, 2014, to August 31, 2015;
- 75 percent from September 1, 2015, to August 31, 2016; and
- All new vehicles starting September 1, 2016.

Thus, the effective date is beyond the scope of this analysis. However, manufacturers have provided a main cost element of ejection mitigation window curtain technology (the rollover sensor) in some of the fleet for several years and we will count the rollover sensor in this analysis as voluntary. In addition, there was one make/model LTV (Mazda CX-9) that met the FMVSS No. 226 standard voluntarily in MY 2007. Since this model met the standard before the NPRM, the cost for this model will be added as voluntary

NHTSA anticipates that the technology used by manufacturers to meet this new standard will be window curtain air bags that deploy in rollovers, stay inflated for six seconds,[194] are large enough to cover the side-window area, and are strong enough to contain the occupant. For this analysis the term we use for these larger window curtains that deploy in a rollover is a rollover window curtain. Rollover window curtains would be needed on all side windows, including both front and rear seats, back to at least the third row.[195] A window curtain air bag designed for side impacts can be upgraded to a rollover window curtain by adding a rollover sensor in the vehicle and modifying the electronic control module that sends the signal to deploy, increasing the height and width of the air bag, adding more gas to fill the larger rollover window curtain, and changing the weave of the window curtain bag fabric so that it maintain sufficient inflation to provide occupant containment for 6 seconds. Window curtains that deploy in rollovers first became available on 2002 Ford Explorers and Mercury Mountaineers (although agency testing indicates that these early curtains would not have met all the requirements of future FMVSS No. 226). As more side-impact window curtains have been upgraded to rollover window curtains over the past 12 years, curtains have generally been designed to cover a larger area and stay inflated longer.

Cost estimates were derived for the Final Regulatory Impact Analysis[196] based on a cost teardown report.[197] Costs for a wider and longer window curtain were estimated based on the area covered in square centimeters for a vehicle with a relatively large window curtain (MY 2004 Honda Accord) compared to a similar sized vehicle that provided the typical sized window curtain for side impacts (MY 2003 Toyota Camry). Neither of these vehicles would have passed the retention requirements of FMVSS No. 226, but they provided reasonable measurements for the increase in window curtain size NHTSA anticipated would be necessary to pass the ejection mitigation test procedure. For a passenger car, the increased weight and cost were estimated to average 0.73 pounds and $10.35. LTVs needed even longer air bags to cover those vehicles with three rows of seats and a few with four rows of seats. Even though the standard only requires up to three rows of seats to be covered, manufacturers have extended the window curtain to the back of the vehicle to anchor the window curtain and cover the additional fourth row for the 0.8 percent of vehicles that have four rows. NHTSA estimates that 36 percent of LTVs would cover three rows of seats or have the window curtain extend into the cargo area to anchor the window curtain at the rear of the vehicle. Factoring in these longer window curtains, the average LTV rollover window curtain would weigh 0.91 pounds and cost $12.98 in 2012 dollars.

Costs for a larger inflator were estimated based on the additional window curtain size that needed to be filled with gas. NHTSA estimated that the propellant and casing for the inflator

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[194] Investigations of rollover crashes show that vehicles may transverse long distances and roll over several times. Unbelted occupants are most often ejected at the end of the rollover sequence. Crash testing indicates that rollover duration ranges up to six seconds.

[195] In vehicles with more than three rows of seats, the standard applies to the first three rows of seats and to 600 mm beyond the third row of seats; see 49 CFR Part 571.226 S5.2.1.2(a).

[196] *Final Regulatory Impact Analysis, FMVSS 226 Ejection Mitigation*, January 2011, NHTSA, Docket No. 2011-0004-0003.

[197] Ludtke & Associates (2004, December). *Perform cost and weight analysis, head protection air bag systems, FMVSS 201* (Report No. DOT HS 809 842, Docket No. 2011-0066-0007). Washington, DC: National Highway Traffic Safety Administration.

needed to increase in size by 28 percent and that this would increase the weight of the inflator and the cost of the inflator. Table 226-1 shows these increases in weight and cost.

Based on testing, it was determined that the tether at the lower part of the window curtain would need to be strengthened to meet the 100 mm displacement requirement. In some cases, the manufacturers would shorten the length of the side window curtain tethers to provide the required tension. Thus, it was assumed that there would be no incremental cost associated with the tethers on average. Similarly, NHTSA believes there will be no cost increase to change the weave in the air bag fabric to keep the air bag inflated for six seconds.

A rollover sensor is needed to detect a rollover and deploy the side air bags and window curtains in the event of a rollover. Only one rollover sensor is needed per vehicle. Based on information supplied by sensor suppliers, it was determined that the cost of a rollover sensor would be similar to the cost of a yaw sensor used for electronic stability control. Thus, the weight and cost of a rollover sensor were estimated to be 0.34 pounds and $41.29.[198]

Table 226-1
Weight (lb) and Cost (2012$) of Improvements
For FMVSS No. 226
Average for Passenger Cars and LTVs

	Passenger Cars		**LTVs**	
Component	**Weight**	**Cost**	**Weight**	**Cost**
Larger Curtain	0.73	$10.35	0.91	$12.98
Larger Inflator	1.32	$2.63	1.66	$3.29
Rollover				
Sensor	0.34	$41.29	0.34	$41.29
Total	2.39	$54.26	2.91	$57.55

NHTSA tested several window curtains during the rulemaking process and only found one LTV (a MY 2007 Mazda CX-9) that could pass all of the test requirements of the final FMVSS No. 226 for rollover window curtains. Thus, there were no fully compliant passenger cars that NHTSA knows about that could be considered as voluntary compliance. However, many manufacturers did provide the largest cost element needed to meet the new FMVSS No. 226, the rollover sensor. Since the baseline date is MY 2010, the percentage of passenger cars and LTVs equipped with rollover sensors in MY 2010 and earlier model years are considered voluntary, the MY 2010 baseline year installation rate is considered voluntary for all MY 2011 and later

[198] Ludtke & Associates. (2006, July 31). Cost and weight analysis of the combined system of electronic stability control (ESC), antilock brakes (ABS), and traction control (TCS), Volume 1. Van Buren Twp., MI: Author. The weight of the yaw rate sensor is an average of 7 MY 2005 vehicles' yaw rate sensors from a cost tear-down study on ESC provided in Docket No. 2011-0066-0005. Cost for a rollover sensor taken from the FRIA at Docket No. 2011-0004-0003 and brought up to 2012$.

passenger cars and LTVs, and the difference between the percentage of the fleet with rollover sensors and the baseline percent for MY 2011 and later are considered attributable.

Data on the percentage of the fleet equipped with rollover sensors was determined by examining the percentage of vehicles equipped with rollover window curtains (although almost all of these vehicles didn't meet the FMVSS No. 226 requirements, they were equipped with a rollover sensor) by model year that was provided in the evaluation[199] of the fatality reduction by side air bags. These estimates were updated with another year of data for this report and passenger cars and LTVs were considered separately. The percentage of the fleet equipped with rollover sensors are provided in Table 226-2 for passenger cars and Table 226-3 for LTVs by model year. Cost data from Table 226-1 for rollover sensors were put into the learning curve and the results are shown in Table 226-2 and Table 226-3.

Table 226-2
Average Weight (lb) and Consumer Cost (2012$) of
Rollover Sensors for FMVSS No. 226 Ejection Mitigation
Passenger Cars

Model Year	Percentage of Fleet	Weight (lb)			Consumer Cost (2012$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
2001	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0
2003	0.36	0.00	0	0.00	$0.17	0	$0.17
2004	0.37	0.00	0	0.00	$0.16	0	$0.16
2005	0.40	0.00	0	0.00	$0.17	0	$0.17
2006	1.14	0.00	0	0.00	$0.44	0	$0.44
2007	1.04	0.00	0	0.00	$0.38	0	$0.38
2008	1.52	0.01	0	0.01	$0.53	0	$0.53
2009	1.33	0.00	0	0.00	$0.45	0	$0.45
2010	7.68	0.03	0	0.03	$2.49	0	$2.49
2011	9.00	0.03	0.00	0.03	$2.41	$0.41	$2.82
2012	12.86	0.03	0.02	0.04	$2.34	$1.58	$3.92

[199] Kahane, C. J. (2014, January). *Updated estimates of fatality reduction by curtain and side air bags in side impacts and preliminary analyses of rollover curtains* (Report No. DOT HS 811 882). Washington, DC: National Highway Traffic Safety Administration.

Table 226-3							
Average Weight (lb) and Consumer Cost (2012$) of							
Rollover Sensors for FMVSS No. 226 Ejection Mitigation							
LTVs							
Model Year	**Percentage of Fleet**	**Weight (lb)**			**Consumer Cost (2012$)**		
		Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
2001	0	0	0	0	0	0	0
2002	1.50	0.01	0	0.01	$0.81	0	$0.81
2003	2.56	0.01	0	0.01	$1.23	0	$1.23
2004	4.22	0.01	0	0.01	$1.88	0	$1.88
2005	8.74	0.03	0	0.03	$3.61	0	$3.61
2006	15.76	0.05	0	0.05	$6.09	0	$6.09
2007	29.90	0.10	0	0.10	$10.84	0	$10.84
2008	46.54	0.16	0	0.16	$16.12	0	$16.12
2009	56.37	0.19	0	0.19	$18.96	0	$18.96
2010	78.35	0.26	0	0.26	$25.38	0	$25.38
2011	82.80	0.26	0.01	0.28	$24.58	$1.40	$25.97
2012	82.80	0.26	0.01	0.28	$23.91	$1.36	$25.27

To determine the voluntary cost and weight of the one LTV make/model NHTSA knows of that passed FMVSS No. 226 early, the percentage of the LTV fleet that the sales of the Mazda CX-9 represent were multiplied by the weights and costs from Table 226-1. That particular model represents less than one-half of one percent of LTV sales. Those results are shown in Table 226-4. We did not include the weight and cost for the rollover sensor itself, since that weight and cost was already counted in Table 226-3. Table 226-5 combines the LTV voluntary costs from rollover sensors with the voluntary costs from early compliance and also shows the attributable costs for rollover sensors that were added after the NPRM for MY 2011 and MY 2012.

Table 226-4							
Average Weight (lb) and Consumer Cost (2012$) of							
Voluntarily Supplied Rollover Window Curtains for FMVSS No. 226 Ejection Mitigation							
LTVs							
Model Year	**Percentage of Fleet**	**Weight (lb)**			**Consumer Cost (2012$)**		
		Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
2006	0	0	0	0	$0.00	0	$0.00
2007	0.19	0.00	0	0.00	$0.03	0	$0.03
2008	0.46	0.01	0	0.01	$0.07	0	$0.07
2009	0.41	0.01	0	0.01	$0.07	0	$0.07
2010	0.45	0.01	0	0.01	$0.07	0	$0.07
2011	0.46	0.01	0	0.01	$0.07	0	$0.07
2012	0.37	0.01	0	0.01	$0.06	0	$0.06
Rollover sensor weight and costs not included, since these were included in Table 226-3.							

Table 226-5							
Average Weight (lb) and Consumer Cost (2012$) of							
FMVSS No. 226 Ejection Mitigation							
LTVs							
Model Year	**Percentage of Fleet**	**Weight (lb)**			**Consumer Cost (2012$)**		
		Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
2001	0	0	0	0	0	0	0
2002	1.50	0.01	0	0.01	$0.81	0	$0.81
2003	2.56	0.01	0	0.01	$1.23	0	$1.23
2004	4.22	0.01	0	0.01	$1.88	0	$1.88
2005	8.74	0.03	0	0.03	$3.61	0	$3.61
2006	15.76	0.05	0	0.05	$6.09	0	$6.09
2007	29.90	0.11	0	0.11	$10.87	0	$10.87
2008	46.54	0.17	0	0.17	$16.20	0	$16.20
2009	56.37	0.20	0	0.20	$19.03	0	$19.03
2010	78.35	0.28	0	0.28	$25.45	0	$25.45
2011	82.80	0.28	0.01	0.29	$24.65	$1.40	$26.05
2012	82.80	0.27	0.01	0.29	$23.97	$1.36	$25.33

SECTION 4 – FMVSS 300, 400, AND 500 SERIES

The FMVSS 300, 400, and 500 series specify requirements for vehicles and components to prevent or reduce the severity of fires, protect occupants from hazards during vehicle operation, and provide safety for low-speed vehicles.

FMVSS No. 301, Fuel system integrity

FMVSS No. 301 took effect on January 1, 1968, (passenger cars), in January 1976 (multipurpose passenger vehicles, trucks, (all LTVs) and buses with a GVWR of 10,000 pounds or less), and on April 1, 1977, (school buses with a GVWR greater than 10,000 pounds). The standard specifies requirements for the integrity of motor vehicle fuel systems. The purpose of this standard is to reduce deaths and injuries occurring from fires that result from fuel spillage during and after motor vehicle crashes and from ingestion of fuels during siphoning. This standard applies to:

- passenger cars
- multipurpose passenger vehicles, trucks, and buses that have a GVWR of 10,000 pounds or less and use fuel with a boiling point above 0 degrees Celsius
- school buses that have a GVWR greater than 10,000 pounds and use fuel with a boiling point above 0 degrees Celsius

On February 3, 1967, (32 FR 2414) NHTSA published a final rule in the Federal Register on FMVSS No. 301 for passenger cars. The NPRM was published in the Federal Register on December 3, 1966, (31 FR 15212) making the baseline date September 1, 1966, or MY 1967. It is believed that most passenger cars met this initial standard by the baseline date without an increase in weight or cost. On August 20, 1973, (38 FR 22397) a final rule was published in the Federal Register extending the standard to LTVs. The NPRM was published in the Federal Register on August 29, 1970, (35 FR 13799) making the baseline date September 1, 1969, or MY 1970.

Originally, cars only had to pass a front impact test into a rigid barrier at 30 mph. Fuel spillage after the impact was not allowed to exceed one ounce while the car was still in motion and five ounces during the first five minutes after the car came to a stop. During the next 25 minutes, fuel spillage could not exceed one ounce during any one-minute interval.[200]

During the 1970s, FMVSS No. 301 was significantly upgraded over a three-year phase-in period.

- Effective September 1, 1975. Passenger cars had to meet a static rollover test. Immediately after the frontal test, the damaged vehicle was slowly rotated 90 degrees, 180 degrees (up-side down), and 270 degrees, holding at each of these positions for five minutes. Fuel spillage could not exceed one ounce during any one-minute interval in this process.

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[200] Parsons, G. G. (1990). *Motor vehicle fires in traffic crashes and the effects of the Fuel System Integrity Standard* (Report No. DOT HS 807 675). Washington, DC: National Highway Traffic Safety Administration.

- Effective September 1, 1976. Passenger cars had to meet 30 mph frontal, oblique frontal and rear-impact tests, plus a 20 mph lateral test, with each test followed by a static rollover test. The cars had the same limits on fuel spillage as in the original frontal test. LTVs with GVWR less than or equal to 6,000 pounds had to meet 30 mph frontal and rear-impact tests followed by the static rollover. LTVs with GVWR of 6,000-10,000 (including small LTV-based school buses) had to meet the frontal test without static rollover.

- Effective September 1, 1977. All LTVs with GVWR of 10,000 pounds or less (including small school buses) had to meet the same requirements as passenger cars: frontal, oblique frontal, rear-impact and lateral tests with subsequent rollover.

These amendments resulted in weight and cost increases. The type and extent of modifications near the time of the MY 1976-78 upgrade varied greatly by make-model. Strategies used by the manufacturers included.[201]

- strengthening the fuel tank or other components of the fuel delivery system
- strengthening the structures that hold the fuel tank in place
- shielding the fuel tank and delivery system from other parts of the vehicle
- relocating parts of the fuel system further away from other parts of the vehicle or areas likely to be damaged during impacts
- relocating other parts of the vehicle further away from the fuel system, or reshaping them to make them less likely to damage the fuel system

On December 1, 2003, (68 FR 67068) NHTSA published a final rule in the Federal Register to upgrade the rear- and lateral-impact test procedures of FMVSS No. 301 for passenger cars and LTVs (sometimes called FMVSS No. 301R for the amended rear impact test). The NPRM was published in the Federal Register on November 13, 2000, (65 FR 67693) making the baseline date September 1, 2000, or MY 2001. The final rule replaced the full rear impact test procedure with an offset rear impact test procedure specifying that only a portion of the width of the rear of the test vehicle be impacted at 50 mph. Under the new rear impact procedure, a lighter deformable barrier is used. The barrier is very similar to the one used for dynamic testing of the side impact protection standard, except that the rear impact barrier’s face is mounted slightly lower to simulate the diving of the front end of a vehicle during pre-crash braking. The new requirements were phased in with compliance required by:

- 40 percent of vehicles manufactured after September 1, 2006, and before September 1, 2007,
- 70 percent of vehicles manufactured after September 1, 2007, and before September 1, 2008, and
- 100 percent of vehicles manufactured after September 1, 2008.

In the same December 1, 2003, final rule, NHTSA changed the side impact test to use the FMVSS No. 214 side impact barrier, effective September 1, 2014. Based on test data, it was

[201] Ibid, 4-11 thru 4-22.

believed that all passenger cars and LTVs would pass this side impact test change with no additional cost.

Passenger Car Studies

Initial MY 1968 standard - Cost analyses by NHTSA did not show any substantive changes from MY 1967 to 1968 needed to meet the original FMVSS No. 301.[202] Statistical analyses of post-crash fire rates did not show a significant difference between pre-1968 and MY 1968+ cars. Based on our evaluation of fire-related crashes NHTSA believes that cars sold in the United States generally would have been capable of meeting the FMVSS No. 301 frontal impact test for some years before the regulation was proposed.

MY 1976 upgrade - Fuel system elements of twelve post-standard (MY 1976) passenger cars and their corresponding pre-standard (MY 1967) make-models were examined to determine the weight and consumer cost of equipment changes in response to FMVSS No. 301.[203] Table 301-1 shows the sales-weighted average weight and consumer cost increase (before applying the learning curve) of implementing the 1976 requirement, with the difference attributable to FMVSS No. 301 in passenger cars because the changes were made after the baseline date. We have no data on percent compliance before the effective date (between 1967 and 1976), so we have assumed 100 percent compliance on the MY 1976 effective date and no compliance before that date. The evaluation indicated that post-standard passenger cars had 14 percent fewer fires than pre-standard passenger cars, after controlling for vehicle age.[204] However, this analysis did not show a statistically significant reduction of post-crash fires for LTVs, nor could it show a statistically significant reduction in post-crash fatalities related to fire. The crash data is not refined enough to determine what percent of pre-MY 1976 vehicles could comply with the standard.

TABLE 301-1
AVERAGE WEIGHT AND CONSUMER COST
OF THE FUEL TANK AND FUEL TANK FILLER TUBE
FMVSS No. 301 IN PASSENGER CARS
MY 1976-78 REQUIREMENTS

CATEGORY	WEIGHT IN POUNDS	CONSUMER COST ($2012)
Pre-Standard	24.14	$56.68
Post-Standard	26.62	$77.06
DIFFERENCE	2.48	$20.38

[202] McLean, R. F., Eckel, C., & Cowan, D. (1978, October). *Cost evaluation for four Federal Motor Vehicle Standards, Volume I*. (Report No. DOT HS 803 871). Washington, DC: National Highway Traffic Safety Administration. Available at www-nrd.nhtsa.dot.gov/Pubs/HS803871.pdf
[203] ,Docket No. 2011-0066-0082Ibid.
[204] Parsons, G. G. (1983, January). *Evaluation of Federal Motor Vehicle Standard 301-75, fuel system integrity: passenger cars*. (Report No. DOT HS 806 335, p. 3). Washington, DC: National Highway Traffic Safety Administration.

Table 301-2 shows the average weight and consumer cost after applying the learning curve for the MY 1976-78 requirements for passenger cars. It assumes 100 percent compliance in MY 1976.

Table 301-2 Average Weight (lb) and Consumer Cost (2012$) of FMVSS No. 301 - MY 1976-78 Requirements Passenger Cars						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1975	0	0	0	$0.00	$0.00	$0.00
1976	0	2.48	2.48	$0.00	$20.38	$20.38
1977	0	2.48	2.48	$0.00	$18.56	$18.56
1978	0	2.48	2.48	$0.00	$17.66	$17.66
1979	0	2.48	2.48	$0.00	$17.11	$17.11
1980	0	2.48	2.48	$0.00	$16.77	$16.77
1981	0	2.48	2.48	$0.00	$16.50	$16.50
1982	0	2.48	2.48	$0.00	$16.28	$16.28
1983	0	2.48	2.48	$0.00	$16.06	$16.06
1984	0	2.48	2.48	$0.00	$15.83	$15.83
1985	0	2.48	2.48	$0.00	$15.62	$15.62
1986	0	2.48	2.48	$0.00	$15.42	$15.42
1987	0	2.48	2.48	$0.00	$15.26	$15.26
1988	0	2.48	2.48	$0.00	$15.12	$15.12
1989	0	2.48	2.48	$0.00	$14.99	$14.99
1990	0	2.48	2.48	$0.00	$14.88	$14.88
1991	0	2.48	2.48	$0.00	$14.79	$14.79
1992	0	2.48	2.48	$0.00	$14.70	$14.70
1993	0	2.48	2.48	$0.00	$14.61	$14.61
1994	0	2.48	2.48	$0.00	$14.52	$14.52
1995	0	2.48	2.48	$0.00	$14.43	$14.43
1996	0	2.48	2.48	$0.00	$14.35	$14.35
1997	0	2.48	2.48	$0.00	$14.28	$14.28
1998	0	2.48	2.48	$0.00	$14.20	$14.20
1999	0	2.48	2.48	$0.00	$14.12	$14.12
2000	0	2.48	2.48	$0.00	$14.05	$14.05
2001	0	2.48	2.48	$0.00	$13.98	$13.98
2002	0	2.48	2.48	$0.00	$13.92	$13.92
2003	0	2.48	2.48	$0.00	$13.85	$13.85
2004	0	2.48	2.48	$0.00	$13.79	$13.79
2005	0	2.48	2.48	$0.00	$13.74	$13.74

2006	0	2.48	2.48	$0.00	$13.68	$13.68
2007	0	2.48	2.48	$0.00	$13.63	$13.63
2008	0	2.48	2.48	$0.00	$13.60	$13.60
2009	0	2.48	2.48	$0.00	$13.56	$13.56
2010	0	2.48	2.48	$0.00	$13.53	$13.53
2011	0	2.48	2.48	$0.00	$13.50	$13.50
2012	0	2.48	2.48	$0.00	$13.46	$13.46

MY 2007-2009 upgrade - The cost of the MY 2007-2009 FMVSS No. 301 upgrade was estimated in a cost teardown study, Cost and Weight Analysis for FMVSS No. 301 Fuel System Integrity Rear Impact Test Upgrade, by Ricardo Inc., October 2014 (Docket No 2011-0066-0089). Ricardo examined 6 vehicles, the MY 1998 and MY 2007 Volkswagen Jetta, MY 1998 and MY 2008 Ford Mustang, MY 1998 and MY 2008 Honda Civic, MY 2000 and MY 2010 Hyundai Elantra, MY 2000 and MY 2007 Toyota RAV4 (a LTV), and the MY 1998 Buick LeSabre and MY 2005 Buick LaCrosse. Of those 6 pre-standard vehicles, the Honda Civic and Ford Mustang passed the test and the remaining 4 vehicles did not.

From research done to determine the impacts of the standard on weight and costs, the following generalizations were made:

- Most FMVSS No. 301R test failures occurred in the fuel neck, but were primarily driven by the routing of the fuel neck from the body side to the fuel tank and its proximity to other parts that moved under test conditions leading to rupture of the tube.
- FMVSS No. 301R did not drive the design of the fuel tank including the choice of steel or plastic materials. The overriding expert opinion was that the design of the body structure should prevent all impingement on the fuel tank under the test conditions. Based on this the fuel tank was not considered an influencing factor in the study.
- For the vehicles and model years analyzed in the study the primary load carrying structure to manage the loads generated by FMVSS No. 301R test is the rear frame rails, so other chassis or body structures such as suspension, and styling were not considered.

The system components contributing to FMVSS No. 301R were broken down into two groups (the fuel filler neck system and structural chassis components) for an in depth analysis of these components:

- Fuel Filler Neck System
- Fuel Cap Assembly and Breather Valve Assembly
- Fuel Filler Neck Assembly - Fuel Filler Neck, Fuel Filler Breather, Tubes, Connectors & Purchased Parts
- Fuel Filler Valve Assembly
- Sub-assembly and Final Assembly Costs
- Structural Chassis Components - Rear Frame Rails, Stiffeners, Patches, Sub-assembly and Final Assembly Costs

The most unusual finding in this FMVSS 301R cost teardown analysis is that the two vehicles that passed the standard in the baseline vehicles (Honda Civic and Ford Mustang) had similar weight and cost increases as the four vehicles that failed the standard in the baseline vehicles.

The reason is that there were major design changes to the rear suspension mountings in many vehicles during this period (including the Honda Civic, Ford Mustang, and Hyundai Elantra in our sample of six vehicles) and components needed to be added that were not on the baseline vehicles to assure compliance with FMVSS 301R.

Table 301-3 shows the estimated incremental average weight and costs for the MY 2007-2009 FMVSS No. 301R requirements for passenger cars. The average cost in 2014$ was $43.24 which was converted into $41.77 in 2012$ by using the gross domestic product price deflator multiplier of 0.9661.[205] Since one of the six vehicles averaged in the teardown study was an LTV, the weight and cost for the LTV was similar to passenger cars, and we have no other cost data on LTVs, we will assume the same cost for LTVs as for passenger cars.

Table 301-3 Weight (lb) and Consumer Cost (2012$) Average Changes Made for FMVSS 301R Passenger Cars and LTVs		
	Weight	**Consumer Cost**
Filler Neck	0.22	$5.36
Structure	18.31	$36.41
Total	18.55	$41.77

The 2014 evaluation[206] estimated compliance with the MY 2007-2009 requirements based on two data sets. First, as part of the evaluation, NHTSA tested a sample of MY 1996 to MY 2000 vehicles to the FMVSS No. 301R final rule, combined them with previous testing, and after weighting them for sales, found that in MY 2005 and earlier, the average compliance rate was 38.55 percent for passenger cars. However, based on the cost teardown study, this does not necessarily mean that there are no weight and cost impacts for that complying part of the fleet. Second, based on compliance data, manufacturers certified compliance for passenger cars during the phase-in period at 45.58 percent for MY 2007, 70.65 percent for MY 2008, and 100 percent for MY 2009 (as required).

The Honda Civic and Ford Mustang cost teardown results present a dilemma in determining what percent of the complying vehicles we should assume have no cost and what percent have a cost. Typically we would assume all complying vehicles have no cost, but that isn't the case here. We know that three of the six vehicles in the cost teardown changed rear suspension mountings and these were three different manufacturers. Without any further information, we will assume that half of the complying vehicles before the phase-in would have to make changes

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[205] Ricardo Inc. (2014, October). *Cost and weight analysis for FMVSS No. 301 Fuel System Integrity Rear Impact Test Upgrade.* (Report found in Docket No. 2011-0066-0089). Van Buren Twp., MI: Summing the data from the two right columns of Table 3 for the six vehicles and dividing by 6; Table 4 is incorrect.

[206] Pai, J. (2014, June). Evaluation of FMVSS No. 301, fuel system integrity, as upgraded in 2005 to 2009. (Report No. DOT HS 812 038). Washington, DC: National Highway Traffic Safety Administration. Available at https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812038

to their vehicles to comply and half would not. This changes the complying percentage without weight and cost impacts from 38.55 percent to 19.28 percent for passenger cars.

We are not assuming any voluntary compliance with the FMVSS No. 301R requirements for several reasons. First, there is no known technology (like an air bag or seat belt) that can be identified as being added to a vehicle to assure compliance with the FMVSS No. 301R test. Without testing there would be no way for NHTSA to determine whether a tank guard or fuel filler neck area that passed the 1976 requirements would have been sufficient to meet the MY 2007-2009 requirements. If those 1976 changes were sufficient to meet the MY 2007-2009 requirements, it wouldn’t be appropriate to count those changes as compliance changes for the 1976 requirements and also as voluntary compliance for the MY 2007-2009 requirements. Second, as shown in the cost teardown analysis, some baseline vehicles that passed the tests still had weight and cost impacts because they changed platforms or made other changes (like in the rear suspension mountings) that required adding components to the vehicle to assure compliance with FMVSS No. 301R.

We are also not assuming a learning curve for the MY 2007-2009 requirements for several reasons. We don’t have historical data on the use of fuel filler neck designs, various structures used or fuel tank guards and it would appear that each make-model demands its own design. While we are sure that there is learning in designing these products, we simply don’t have a good feel for whether applying the 0.93 learning factor makes sense here. In addition, the time frame from MY 2007 to 2012 is fairly short and any learning would have very little impact on costs.

As a result, we believe the best method for estimating the incremental costs for the MY 2007-2009 requirements is to apply the weight and cost to the percentage of the fleet complying in each of the phase-in years where we have known compliance data based on certifications from the manufacturers, and subtracting assumed compliance (19.28%) found in years prior to the effective dates to obtain an incremental compliance percentage to multiply by the average weight and cost from Table 301-3. This results in the following percentage of the fleet having incremental weights and costs attributable for FMVSS No. 301R – MY 2007 = 26.31 percent, MY 2008 = 51.38 percent, and MY 2009 and thereafter = 80.73 percent.

Table 301-4 shows the estimated incremental weights and costs for passenger cars for FMVSS No 301R for the MY 2007 requirements.

Table 301-4						
Average Weight (lb) and Consumer Cost (2012$) of						
FMVSS No. 301R - MY 2007 Requirements						
Passenger Cars						
Model Year	Weight (lb)			Consumer Cost (2012$)		
	Voluntary	Attr.	Total	Voluntary	Attr.	Total
2006	0	0	0	$0.00	$0.00	$0.00
2007	0	4.88	4.88	$0.00	$10.99	$10.99
2008	0	9.52	9.52	$0.00	$21.46	$21.46
2009	0	14.96	14.96	$0.00	$33.72	$33.72
2010	0	14.96	14.96	$0.00	$33.72	$33.72
2011	0	14.96	14.96	$0.00	$33.72	$33.72
2012	0	14.96	14.96	$0.00	$33.72	$33.72

LTV Studies

FMVSS No. 301 was extended to LTVs in January 1976. To determine the weight and consumer cost of the equipment changes in response to FMVSS No. 301 requirements fuel system elements of two pre-standard (MY 1976) LTVs and their corresponding post-standard (MY 1977) make-models were examined.[207]

Examination of the 1976 and 1977 model year LTVs did not make a clearly defined conclusion on the implementation of the standard. One selected vehicle indicated an increase in weight of 11.73 pounds and cost of $11.64 in 2012 dollars, while the other vehicle exhibited no cost or weight increase from MY 1976 to MY 1977. Because of the small sample size and the possibility that the vehicle with no change could have made the equipment changes a year earlier, we prefer to attribute the full weight and cost imposed for passenger cars to LTVs. We have no data on percent compliance before the effective date, so we have assumed 100 percent compliance on the MY 1977 effective date for LTVs and no compliance before that date.

Table 301-5 shows the sales-weighted average weight and cost for the MY 1977-78 requirements for LTVs. Table 301-6 shows the sales-weighted average weight and consumer cost (after applying the learning curve) of implementing the MY 1977 requirement, with the difference attributable to FMVSS No. 301 in LTVs. The weight added per year is 2.48 pounds for every model year from 1977 to 2012, while the cost per year is determined by the learning curve.

[207] McLean, Eckel, & Cowan, DOT HS 803 871, 1978.

TABLE 301-5 AVERAGE WEIGHT AND CONSUMER COST OF THE FUEL TANK AND FUEL TANK FILLER TUBE FMVSS No. 301 IN LTVS MY 1977-78 REQUIREMENTS		
CATEGORY	**WEIGHT IN POUNDS**	**CONSUMER COST ($2012)**
Pre-Standard	24.14	$56.68
Post-Standard	26.62	$77.06
Difference	2.48	$20.38

Table 301-6 Average Weight (lb) and Consumer Cost (2012$) of FMVSS No. 301 - MY 1976-78 Requirements LTVs						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
1975	0	0	0	$0.00	$0.00	$0.00
1976	0	0	0	$0.00	$0.00	$0.00
1977	0	2.48	2.48	$0.00	$18.56	$18.56
1978	0	2.48	2.48	$0.00	$17.66	$17.66
1979	0	2.48	2.48	$0.00	$17.11	$17.11
1980	0	2.48	2.48	$0.00	$16.77	$16.77
1981	0	2.48	2.48	$0.00	$16.50	$16.50
1982	0	2.48	2.48	$0.00	$16.28	$16.28
1983	0	2.48	2.48	$0.00	$16.06	$16.06
1984	0	2.48	2.48	$0.00	$15.83	$15.83
1985	0	2.48	2.48	$0.00	$15.62	$15.62
1986	0	2.48	2.48	$0.00	$15.42	$15.42
1987	0	2.48	2.48	$0.00	$15.26	$15.26
1988	0	2.48	2.48	$0.00	$15.12	$15.12
1989	0	2.48	2.48	$0.00	$14.99	$14.99
1990	0	2.48	2.48	$0.00	$14.88	$14.88
1991	0	2.48	2.48	$0.00	$14.79	$14.79
1992	0	2.48	2.48	$0.00	$14.70	$14.70
1993	0	2.48	2.48	$0.00	$14.61	$14.61
1994	0	2.48	2.48	$0.00	$14.52	$14.52
1995	0	2.48	2.48	$0.00	$14.43	$14.43
1996	0	2.48	2.48	$0.00	$14.35	$14.35
1997	0	2.48	2.48	$0.00	$14.28	$14.28
1998	0	2.48	2.48	$0.00	$14.20	$14.20
1999	0	2.48	2.48	$0.00	$14.12	$14.12
2000	0	2.48	2.48	$0.00	$14.05	$14.05

2001	0	2.48	2.48	$0.00	$13.98	$13.98
2002	0	2.48	2.48	$0.00	$13.92	$13.92
2003	0	2.48	2.48	$0.00	$13.85	$13.85
2004	0	2.48	2.48	$0.00	$13.79	$13.79
2005	0	2.48	2.48	$0.00	$13.74	$13.74
2006	0	2.48	2.48	$0.00	$13.68	$13.68
2007	0	2.48	2.48	$0.00	$13.63	$13.63
2008	0	2.48	2.48	$0.00	$13.60	$13.60
2009	0	2.48	2.48	$0.00	$13.56	$13.56
2010	0	2.48	2.48	$0.00	$13.53	$13.53
2011	0	2.48	2.48	$0.00	$13.50	$13.50
2012	0	2.48	2.48	$0.00	$13.46	$13.46

For the MY 2007-2009 FMVSS No. 301R upgrade, the average weights and costs for LTVs are shown in Table 301-3.

The 2014 Evaluation[208] estimated compliance with the MY 2007-2009 requirements based on two data sets. First, as part of the evaluation, NHTSA tested a sample of MY 1996 to MY 2000 vehicles to the FMVSS No. 301 final rule, combined them with previous testing by NHTSA, and after weighting them for sales, found that in MY 2005 and earlier, the average compliance rate was 48.63 percent for LTVs. As discussed in the passenger car section, we will assume that half of the complying vehicles before the phase-in would have to make changes to their vehicles to comply and half would not. This changes the complying percentage without weight and cost impacts from 48.63 percent to 24.32 percent for LTVs. Second, based on compliance data, manufacturers certified compliance for LTVs during the phase-in period at 64.48 percent for MY 2007, 85.94 percent for MY 2008, and 100 percent for MY 2009 (as required). This results in the following percentage of the fleet having incremental weights and costs attributable for FMVSS No. 301R – MY 2007 = 40.17 percent, MY 2008 = 61.63 percent, and MY 2009 and thereafter = 75.69 percent.

As discussed in the passenger car section, we are not assuming any voluntary compliance with the FMVSS No. 301R requirements and we are not estimating a learning curve for the MY 2007-2009 requirements.

Table 301-7 shows the estimated incremental weight and costs for the MY 2007-2009 FMVSS No. 301R requirements for LTVs.

[208] Pai, 812 038, 2014.

Table 301-7						
Average Weight (lb) and Consumer Cost (2012$) of						
FMVSS No. 301R - MY 2007 Requirements						
LTVs						
Model Year	**Weight (lb)**			**Consumer Cost (2012$)**		
	Voluntary	**Attr.**	**Total**	**Voluntary**	**Attr.**	**Total**
2006	0	0	0	$0.00	$0.00	$0.00
2007	0	7.44	7.44	$0.00	$16.78	$16.78
2008	0	11.42	11.42	$0.00	$25.74	$25.74
2009	0	14.02	14.02	$0.00	$31.62	$31.62
2010	0	14.02	14.02	$0.00	$31.62	$31.62
2011	0	14.02	14.02	$0.00	$31.62	$31.62
2012	0	14.02	14.02	$0.00	$31.62	$31.62

FMVSS No. 302, Flammability of Interior Materials

FMVSS No. 302 took effect on September 1, 1972, and specifies burn resistance requirements for materials used in the occupant compartments of motor vehicles. The purpose of the standard is to reduce the deaths and injuries to motor vehicle occupants caused by vehicle fires, especially those originating in the interior of the vehicle from sources such as matches or cigarettes. This standard applies to passenger cars, multipurpose passenger vehicles, trucks, (all LTVs) and buses. No cost studies of this standard have been done, and none are planned by NHTSA.

FMVSS No. 303, Fuel system integrity of compressed natural gas vehicles

FMVSS No. 303 took effect on April 25, 1994, and specifies requirements for the integrity of motor vehicle fuel systems using compressed natural gas (CNG), including the CNG fuel systems of bi-fuel, dedicated, and dual fuel CNG vehicles. The purpose of the standard is to reduce deaths and injuries occurring from fires that result from fuel leakage during and after motor vehicle crashes. This standard applies to passenger cars, multipurpose passenger vehicles, trucks, (all LTVs) and buses that have a GVWR of 10,000 pounds or less and school buses regardless of weight that use CNG as a motor fuel. There are very few light vehicles powered by CNG in the fleet. No cost studies of this standard have been done, and none are currently planned by NHTSA.

FMVSS No. 304, Compressed natural gas fuel container integrity

FMVSS No. 304 took effect March 27, 1995, and specifies requirements for the integrity of CNG, motor vehicle fuel containers. The purpose of this standard is to reduce deaths and injuries occurring from fires that result from fuel leakage during and after motor vehicle crashes. This standard applies to each passenger car, multipurpose passenger vehicle, truck, (all LTVs) and bus that use CNG as a motor fuel and to each container designed to store CNG as motor fuel on-board any motor vehicle. No cost studies of this standard have been done, and none are currently planned by NHTSA.

FMVSS No. 305, Electric-powered vehicles: electrolyte spillage and electrical shock protection

FMVSS No. 305 took effect on September 27, 2000, and specifies requirements for limitation of electrolyte spillage, retention of propulsion batteries during a crash, and electrical isolation of the chassis from the high-voltage system to be met by vehicles that use electricity as propulsion. The purpose of this standard is to reduce deaths and injuries during a crash that occur because of electrolyte spillage from propulsion batteries, intrusion of propulsion battery system components into the occupant compartment, and electrical shock. This standard applies to passenger cars and to multipurpose passenger vehicles, trucks, (all LTVs) and buses with a GVWR of 10,000 pounds or less, that use more than 48 nominal volts of electricity as propulsion power and whose speed attainable in 1.6 km on a paved level surface is more than 40 km/h. No cost studies of this standard have been done, and none are currently planned by NHTSA.

FMVSS No. 401, Interior trunk release

FMVSS No. 401 took effect on September 1, 2001, (MY 2002) and establishes the requirements for providing an interior trunk release mechanism that makes it possible for a person trapped inside the trunk compartment of a passenger car to escape from the compartment. The standard was intended to give children that trapped themselves in a trunk and the victims of crime that were forced into a trunk the chance to free themselves. This standard applies to passenger cars that have a trunk compartment. It does not apply to passenger cars with a back door; thus, it does not apply to station wagons or hatchbacks. The analysis to determine the percentage of the passenger car fleet affected by the standard was completed using Polk data. For analysis by body style, the standard applied to convertibles, 2-door passenger cars and 4-door passenger cars; it does not apply to 3-door passenger cars and 5-door passenger cars and station wagons. FMVSS No. 401 also does not apply to LTVs, since none have ever been produced with a trunk lid. No cost teardown studies of this standard have been done, and none are currently planned by NHTSA. In addition, no regulatory evaluation or regulatory impact analysis was completed for the NPRM (published on December 17, 1999, at 64 FR 07672) or final rule. However, in the preamble to the final rule, which was published in the Federal Register on October 20, 2000, (65 FR 63014), NHTSA estimated the cost for an interior trunk release pull handle (which are now commonly glow-in-the-dark) at $2.00. Since this estimate was in year 2000 dollars, the estimated cost in 2012 dollars is $2.56 ($2.00 * 1.2822). The 1.2822 multiplier is used to adjust the estimated cost from 2000 economics to 2012 economics based on the implicit GDP price deflator. No weight estimate was made in the final rule. For purposes of this analysis, we assume that a plastic handle with a short cable to attach it to the trunk release mechanism would weigh about 0.1 pounds.

During the rulemaking, Ford stated that all of its MY 2000 passenger cars would come equipped with an interior trunk release mechanism. We assume Ford was referring to all passenger cars that have a trunk lid and would not count station wagons and hatchbacks. With the exception of Ford for MY 2000 and MY 2001, we know of no other manufacturer that supplied an interior trunk release handle before the MY 2002 effective date. The baseline for FMVSS No. 401 is September 1, 1999, or MY 2000. Thus, the percentage of passenger cars equipped with interior trunk releases in MY 2000 are considered voluntary, the MY 2000 baseline year installation rate (14.1% installation for passenger cars) is considered voluntary for all MY 2000 and later passenger cars. Actually, Ford's sales in MY 2001 decreased relative to other manufacturers and only 13.1 percent of the fleet had interior trunk releases in MY 2001. The difference between the percentage of the fleet with interior trunk releases and 14.1 percent for passenger cars for MY 2002 and later are considered attributable.

Table 401-1 shows the percentage of passenger cars that were estimated to meet FMVSS No. 401 by model year, and the average weight and cost impacts.

Table 401-1
Average Weight (lb) and Consumer Cost (2012$) of
FMVSS No. 401 Interior Trunk Release
Passenger Cars

Model Year	Percent Of Fleet	Weight (lb)			Consumer Cost (2012$)		
		Voluntary	Attr.	Total	Voluntary	Attr.	Total
2000	14.12	0.01	0.00	0.01	$0.45	$0.00	$0.45
2001	13.13	0.01	0.00	0.01	$0.39	$0.00	$0.39
2002	91.30	0.01	0.08	0.09	$0.36	$1.98	$2.34
2003	90.50	0.01	0.08	0.09	$0.34	$1.85	$2.19
2004	91.50	0.01	0.08	0.09	$0.33	$1.81	$2.14
2005	89.30	0.01	0.08	0.09	$0.32	$1.71	$2.03
2006	89.80	0.01	0.08	0.09	$0.31	$1.69	$2.00
2007	86.60	0.01	0.07	0.09	$0.31	$1.59	$1.90
2008	87.00	0.01	0.07	0.09	$0.31	$1.58	$1.88
2009	86.80	0.01	0.07	0.09	$0.30	$1.56	$1.86
2010	84.90	0.01	0.07	0.08	$0.30	$1.50	$1.80
2011	87.40	0.01	0.07	0.09	$0.30	$1.54	$1.84
2012	87.40	0.01	0.07	0.09	$0.29	$1.53	$1.82

FMVSS No. 402 – [Does not currently exist]

FMVSS No. 403, Platform lift systems for motor vehicles

FMVSS No. 403 took effect on December 27, 2004, and specifies requirements for platform lifts used to assist persons with limited mobility in entering or leaving a motor vehicle. The purpose of this standard is to prevent injuries and fatalities to passengers and bystanders during the operation of platform lifts installed in motor vehicles. This standard applies to platform lifts designed to carry passengers into and out of motor vehicles. No cost teardown studies of this standard have been done, and none are currently planned by NHTSA. However, cost estimates were made in the Final Regulatory Evaluation supporting the final rule.

The final rule that was published in the Federal Register on December 27, 2002, (67 FR 79416) essentially only affects LTVs. NPRMs were published on July 27, 2000, (65 FR 46228) and February 26, 1993, (58 FR 11562).

The final rule sets a wide variety of standards, including minimum sizes for platforms, performance standards for strength and slip resistance. It requires handrails, threshold warning signals, retainer barriers and interlocks to keep the lift from operating while the vehicle is in motion, etc. Most platform lifts sold are for public use – transit buses, motorcoaches, over-the-road and charter buses, and school buses. However, some are sold for private use for vehicles with GVWR of 10,000 pounds or less and are typically installed in vans. Many wheelchair occupants use ramps to enter vans, but the standard does not apply to ramps, but to platform lifts. Platform lifts for the larger public-use vehicles are required to meet more parts of the standard than are platforms lifts designed for the smaller private use vehicles.

There is not much data on how many private-use vehicles are converted per year to include a platform lift. In the Final Regulatory Evaluation[209] it was estimated that between 8,800 and 17,000 vehicles are converted each year to include platform lifts for private use. Since the United States armed forces have been involved in combat operations since before the effective date of this rule, for this analysis, we'll assume the higher level of 17,000. We will also assume that essentially all of these conversions are for LTVs and essentially none are for passenger cars.

Almost all of these platforms lifts for private use on LTVs are installed as aftermarket equipment and are not installed by the original equipment manufacturer. Because they are aftermarket equipment, their costs do not fit into the focus of this report, that is What is the cost added to the average passenger car and LTV due to the FMVSS? If an original equipment manufacturer entered into a contract with a platform lift manufacturer and had the lift provided as an option on a new vehicle, then that lift would be considered original equipment. But that has not been the typical business practice. Typically, on paper, the vehicle dealer sells the vehicle to the customer and then has it shipped to another firm that installs the platform lift, and then brings it back to the customer. Many other customers have lifts installed on used vehicles. Vehicles under either of these business practices are considered aftermarket vehicles.

The Final Regulatory Evaluation estimated the cost increase for those new parts required by the standard for platform lifts to be $184.26 in 2012 dollars before applying the learning curve. This

[209] NHTSA. (2002, November 27). *Final Regulatory Evaluation and Regulatory Flexibility Analysis, Platform Lift Systems for Motor Vehicles, FMVSS No. 403 and 404,* Washington, DC, Docket No. 2002-13917-0003.

included a high-contrast standee platform marking, control-system lettering size and illumination, threshold-warning device and visual/audible signal, occupied-outer-barrier interlock device, and a lift-interlock relay switch. Even though the Final Regulatory Evaluation did not estimate the incremental weight of the new devices required, two of these improvements (markings and illumination) add almost no weight, while the others are electronic devices which add very little weight. Combined, we estimate the incremental weight for LTVs affected to be 1.0 pounds.

For this analysis, we estimated the weight and cost impact if platform lifts were original equipment, just to see how it would affect the estimates. The average weight and cost impact for LTVs fluctuates, because we assumed constant sales of 17,000 platform lifts, while sales of LTVs fluctuate each year. The cost impact would average between $0.33 and $0.53 per vehicle over the 2005-2012 model year time period. After averaging platform lift sales into all LTV sales, the weight impact comes out to 0.003 pounds and is rounded down to 0.00 pounds.

Since these are considered aftermarket sales, these weights and costs have not been added into the summary tables as part of the average weight and cost impact of the FMVSS on LTVs. These weight and cost impacts are borne by the purchasers of platform lifts, or the government, and are not part of the price that an average consumer pays for an LTV.

FMVSS No. 404, Platform lift installations in motor vehicles

FMVSS No. 404[210] took effect on December 27, 2004, and specifies requirements for vehicles equipped with platform lifts used to assist persons with limited ability in entering or leaving a motor vehicle. The purpose of this standard is to prevent injuries and fatalities to passengers and bystanders during the operation of platform lifts installed in motor vehicles. This standard applies to motor vehicles equipped with a platform lift to carry passengers into and out of the motor vehicle. No cost teardown studies of this standard have been done, and none are currently planned by NHTSA. However, cost estimates made in the rulemaking process were combined with the discussion related to FMVSS No. 403.

FMVSS No. 500, Low-speed vehicles

FMVSS No. 500 took effect on June 17, 1998, and specifies requirements for low-speed vehicles to ensure that low-speed vehicles operated on the public streets, roads, and highways are equipped with minimum motor vehicle equipment appropriate for motor vehicle safety. A low-speed vehicle is a four-wheeled motor vehicle, other than a truck, whose top speed is greater than 20 mph, but not greater than 25 mph. Low speed vehicles are required to meet a very limited set of motor vehicle safety standards. As such, low speed vehicles are not really comparable to passenger cars and LTVs from a motor vehicle safety cost perspective. Neither their sales nor their costs have been included in this analysis. No cost studies of this standard have been done, and none are currently planned by NHTSA.

[210] The final rule establishing FMVSS No. 403 and No. 404 was published December 27, 2002, at 67 FR 79416, and appears in Docket No. 2002-13917-0001.

APPENDIX A:
LEARNING CURVE SENSITIVITY ANALYSIS

Since the learning curve is an important concept that affects the overall cost estimate, it is appropriate to determine how sensitive the results are based on the assumptions made in the analysis related to the learning curve. Based on cost teardown data, Table 5 presents the progress rates for five safety technologies. The main analysis uses the progress rates derived for those five technologies, and extends them to other very similar technologies (for example we applied a 0.96 progress rate to all manual safety belt technologies), and then uses an average progress rate of 0.93 for all of the other safety technologies not in Table 5.

The goal of this exercise is to determine how sensitive the cost estimates are based on an analysis reflecting a range of possible learning rates. We view this as a useful exercise if only to indicate the possible degree of error in our estimates due to learning.

For this exercise we are comparing the total cost and the trend in costs of 5 calculations for both passenger cars and LTVs. Based on the estimates of progress rates in Table 5, we have chosen the highest (0.96), lowest (0.87), and average (0.93) progress rates and applied them to every safety technology where we had applied learning before. We compare those to the results from the main analysis, along with the costs if we assumed no learning at all. The No Learning sensitivity analysis takes cost estimates from the teardown studies and assumes, for example:

If there is only one teardown analysis (for MY 2000 vehicles), the same costs are applied to every model year that the technology was installed (MY 1990 to MY 2012 in this example).

If there are two teardown analyses (for MY 1992 and MY 2000) and there was no specific knowledge about when technology or costs changed, the MY 1992 costs apply to the MY 1990 to MY 1992 vehicles, a linear interpolation of costs between the two years would apply to MY 1993 to MY 1999 vehicles, then the MY 2000 costs would apply to MY 2000 to MY 2012 vehicles.

Table A-1 presents the results of the learning curve sensitivity analysis for MY 2012 vehicles. Total costs are compared to the main analysis results on a dollar basis and a percentage basis, and total costs are compared to the average price of a passenger car and LTV. Several observations about the results of Table A-1 are:

- The impact of applying the learning curve, compared to assuming that there is no learning taking place for MY 2012 vehicles, are \$250.95 for passenger cars and \$240.93 for LTVs. This amounts to a reduction in estimated safety costs of 13.0 percent for passenger cars and 13.3 percent for LTVs by applying the main analysis learning curve assumptions.
- There is essentially no difference in costs of applying a progress rate of 0.93 compared to the main analysis. This would be expected since we assume 0.93 progress rate for all safety technologies for which we don’t have specific data. The difference for passenger cars is -\$0.36 and the difference for LTVs is -\$3.00.

- The difference in costs of applying a progress rate of 0.96 compared to the main analysis is $102.34 for passenger cars and $99.65 for LTVs. The percentage difference ranges from 5.3 to 5.5 percent.
- The difference in costs of applying a progress rate of 0.87 compared to the main analysis is -$182.29 for passenger cars and -$183.28 for LTVs. The percentage difference ranges from -9.4 to -10.1 percent.
- The difference in the percentage of the cost of a new passenger car or LTV that the FMVSS costs comprise, given that a progress rate of 0.87, 0.93, 0.96, no learning, or the main analysis range from 6.8 to 8.5 percent for passenger cars and 4.8 to 6.0 percent for LTVs.

Table A-1				
Sensitivity Analysis of Learning Curve Costs for MY 2012 Vehicles				
Voluntary and Attributable Costs				
(in 2012 dollars)				
Passenger Cars Progress Rate	**Cost**	**Difference From Main Analysis**		**Percentage of Average Cost of Car $25,553**
		$	**Ratio**	
0.87	$1,747.14	-182.29	0.906	6.8%
0.93	$1,929.07	-$0.36	1.000	7.5%
Main Analysis	$1,929.43	$0.00	1.000	7.6%
0.96	$2,031.77	$102.34	1.053	8.0%
No Learning	$2,180.39	$250.95	1.130	8.5%
LTVs Progress Rate	**Cost**	**Difference From Main Analysis**		**Percentage of Average Cost of LTV $34,078**
		$	**Ratio**	
0.87	$1,624.66	-183.28	0.899	4.8%
0.93	$1,804.94	-$3.00	0.998	5.3%
Main Analysis	$1,807.94	$0.00	1.000	5.3%
0.96	$1,907.59	$99.65	1.055	5.6%
No Learning	$2,048.87	$240.93	1.133	6.0%

Table A-2 presents a sensitivity analysis of different progress rates over time. Table A-3 shows how those results compare to the main analysis. Several observations about the results of Table A-2 and Table A-3 are:

- As a reminder of how the learning curve works, if we have a cost estimate for MY 2000 vehicles, the learning curve will assign higher costs for model years prior to MY 2000 based on the learning curve going backwards and lower costs for model years after MY 2000 as manufacturers learn how to produce their products more efficiently. The results of this method appear in MY 1970 when the costs with progress rates can be slightly higher than the costs with no learning.
- For some of the more important early standards, NHTSA had multiple teardown studies years apart. As a result, the learning curve was not used for some of the standards in the early years and the teardown results were used for cost estimation.

- Comparing the main analysis to no learning in Table A-3 (dividing estimated costs for no learning at the 1.00 progress rate by estimated costs of the main analysis), the impact of the learning curve is relatively small in MY 1970 to MY 1990. The impact of the learning curve grows over time as more years accumulate and more technologies are added. By MY 2012, if a learning curve was not assumed, costs would be 13 percent higher for both passenger cars and LTVs.
- For MYs 1980 to 2012 shown in Table A-2, costs typically increase as the progress rate increases from 0.87, to 0.93, to 0.96, and to no learning, with the exception of LTVs in MY 1990. The ups and downs of the LTV costs in MY 1990 can be explained by examining how rear-wheel ABS costs were estimated. Because ABS was one of the technologies used to determine progress rates in Table 5, the 0.87 progress rate was used for both the main analysis and the 0.87 sensitivity analysis (both had an average cost per LTV of rear-wheel ABS of $480.24), and the costs are fairly close to the no learning sensitivity analysis ($494.23). In comparison, the 0.93 sensitivity cost for MY 1990 LTVs was $367.48 ($113 less than the main analysis) and the 0.96 sensitivity cost for MY 1990 LTVs was $323.53 ($157 less than the main analysis). These large differences in the MY 1990 LTV rear-wheel ABS costs explain most of the differences in costs in the sensitivity analysis for LTVs in MY 1990.

Table A-2 Sensitivity Analysis of Learning Curve Costs Over Time Voluntary and Attributable Costs (in 2012 dollars)						
Passenger Cars Progress Rate	**MY 1970**	**MY 1980**	**MY 1990**	**MY 2000**	**MY 2010**	**MY 2012**
0.87	$315.50	$384.15	$682.56	$1,263.43	$1,723.63	$1,747.14
0.93	$306.23	$394.00	$685.03	$1,287.42	$1,873.95	$1,929.07
Main Analysis	$307.30	$393.45	$703.28	$1,305.65	$1,878.19	$1,929.43
0.96	$302.40	$399.34	$689.34	$1,302.45	$1,958.64	$2,031.77
No Learning	$305.03	$416.90	$740.10	$1,393.41	$2,078.11	$2,180.39
Change from Main Analysis to No Learning	0.99	1.06	1.05	1.07	1.11	1.13
LTVs Progress Rate	**MY 1970**	**MY 1980**	**MY 1990**	**MY 2000**	**MY 2010**	**MY 2012**
0.87	$134.56	$261.21	$775.94	$1,200.35	$1,655.11	$1,624.66
0.93	$131.54	$262.61	$678.29	$1,220.72	$1,806.00	$1,804.94
Main Analysis	$131.33	$260.44	$795.34	$1,244.25	$1,812.51	$1,807.94
0.96	$130.29	$263.82	$642.96	$1,233.27	$1,891.52	$1,907.59
No Learning	$128.87	$266.03	$832.94	$1,341.91	$1,983.36	$2,048.87
Change from Main Analysis to No Learning	0.98	1.02	1.05	1.08	1.09	1.13

Table A-3						
Change in Costs Comparing						
Different Progress Rate Cost to Main Analysis Cost						
Voluntary and Attributable Costs						
Passenger Car Progress Rate	**MY 1970**	**MY 1980**	**MY 1990**	**MY 2000**	**MY 2010**	**MY 2012**
0.87	1.03	0.98	0.97	0.97	0.92	0.91
0.93	1.00	1.00	0.97	0.99	1.00	1.00
Main Analysis	1.00	1.00	1.00	1.00	1.00	1.00
0.96	0.98	1.01	0.98	1.00	1.04	1.05
No Learning	0.99	1.06	1.05	1.07	1.11	1.13
LTV Progress Rate	**MY 1970**	**MY 1980**	**MY 1990**	**MY 2000**	**MY 2010**	**MY 2012**
0.87	1.02	1.00	0.98	0.96	0.91	0.90
0.93	1.00	1.01	0.85	0.98	1.00	1.00
Main Analysis	1.00	1.00	1.00	1.00	1.00	1.00
0.96	0.99	1.01	0.81	0.99	1.04	1.06
No Learning	0.98	1.02	1.05	1.08	1.09	1.13

APPENDIX B:
LEARNING CURVE APPLICATION FACTORS

Table B-1
Learning Curve Application Factors
Passenger Cars

FMVSS	Description	Base Teardown Model Year	Attributable Model Year	Learning Applied to Model Years	Learning Rate
105	Antilock Braking System (ABS) Four-wheel	2005	2008	1986 – 2012	13 %
105	Antilock Braking System (ABS) Rear-wheel	2005	2008	1987-1989	13%
105	Power Booster	1977, but previous estimates in 1966, 1968, and 1976	1972	1978 – 2012	7 %
108	Side Marker Lamps	1980, but previous estimates in 1969 and 1970	1968	1982 – 2012	7 %
108	Center High Mounted Stop Lamps	1986	1985	1985 – 2012	7 %
111	Rear Visibility Cameras	2010	2012	2008 – 2012	7 %
118	Power Windows	1982	1971	1971 – 2012	7 %
124	Accelerator Controls	1982	1973	1973 – 2012	7 %
126	Electronic Stability Control	2005	2008	1998 – 2012	7 %
138	Tire Pressure Monitoring System	2008	2002	2001 – 2012	7 %
139	Tire Upgrade	2003	2003	2003 – 2012	7 %
201	Glove Box Doors and Seat Back Padding	1968	1968	1968 – 2012	7 %
201	Upper Interior Protection	2001	1999	1999 – 2012	7 %
202	Head Restraints Front Outboard	1978	1969	1968 – 2012	9 %

202	Head Restraints Front Outboard Upgrade	2010	2009	2009 – 2012	9 %
202	Head Restraints Rear	1978	N.A., all voluntary	1992 – 2012	9 %
203/204	Steering Assembly	1969	1968	1968 – 2012	7 %
207	Seat Back Locks	1986, with previous estimate in 1969	1968	1981 – 2012	7 %
208	Lap belts – front seat outboard	1973, with previous estimates in 1968	1967	Not used	4 %
208	Lap belts – front seat center	1980, with previous estimates in 1968-74	1967	1968 - 2012	4 %
208	Lap belts – rear seat outboard	1980, with both earlier and later estimates	1967	1972 - 1989	4 %
208	Lap belts – rear seat center	1992, with several previous estimates	1967	1968 – 2012	4 %
208	Lap/shoulder – front seat outboard	1992, with several previous estimates	1973	1992 – 2012	4 %
208	Lap/shoulder – rear seat outboard	1990, with previous estimate in 1971	1989	1972 – 2012	4 %
208	Lap/shoulder – rear seat center	1996	2003	1994 – 2012	4 %
208	Automatic belt – front seat outboard	1987	1987	Not used	N.A.
208	Air bag - driver	2007, plus 1987 and 1992-1996	1985	2007 – 2012	7 %
208	Air bag – passenger	2007, plus 1992-1996	1987	2004 – 2012	7 %
208	Pretensioners and load limiters	1999	N. A., all voluntary	1995 – 2012	4 %
208	Adjustable anchors	1999	1994	1989 - 2012	4 %

208	Manual on-off Switch	1998	N. A., all voluntary	1997 – 2012	7 %
214	Side Door Beams	1979	1970	1969 - 2012	7 %
214	Dynamic Test	1996	1994	1994 - 2012	7 %
214	Side Air Bags/Window Curtains	2001	2005	1996 - 2012	7 %
216	Roof Crush Initial Standard	1974	1974	1974 - 2012	7 %
216	Roof Crush Upgrade	2008	2012	Not used	N.A.
225	LATCH - Lower Anchors and Tethers for Children	2012	2000	2000 - 2012	7 %
226	Ejection Mitigation - Rollover Sensor	2005	2011	2003 - 2012	7 %
301	Fuel System Integrity 1976-78	1976	1976	1976 - 2012	7 %
301	Fuel System Integrity - 2007-2009	2005 – 2010	2007	Not Used	N.A.
401	Interior Trunk Release	2002	2002	2000 - 2012	7 %

Table B-2
Learning Curve Application Factors
LTVs

FMVSS	Description	Base Teardown Model Year	Attributable Model Year	Learning Applied to Model Years	Learning Rate
105	Antilock Braking System (ABS) Four-Wheel	2005	2008	1989 – 2012	13 %
105	Antilock Braking System (ABS) Rear-Wheel	2005	2008	1987-2003	13 %
105	Power Booster	1977, but previous estimates in 1966, 1968, and 1976	1972	1978 – 2012	7 %
105	Brake Warning Light	1984	1984	1968 – 2012	7 %
108	Side Marker Lamps	1980, but previous estimates in 1969 and 1970	1968	1982 – 2012	7 %
108	Center High Mounted Stop Lamps	1986	1991	1991 – 2012	7 %
111	Rear Visibility Cameras	2010	2012	2008 – 2012	7 %
118	Power Windows	1982	MPVs 1978 Trucks 1988	1978 – 2012	7 %
124	Accelerator Controls	1982	1973	1973 – 2012	7 %
126	Electronic Stability Control	2005	2008	1999 – 2012	7 %
138	Tire Pressure Monitoring System	2008	2002	2001 – 2012	7 %
139	Tire Upgrade	2003	2003	2003 – 2012	7 %
201	Glove Box Doors	1979	1980	1979 – 2012	7 %
201	Instrument Panel	1979	1980	1976 – 2012	7 %
201	Seat Back Padding	1979	1980	1980 – 2012	7 %
201	Upper Interior Protection	2001	1999	1999 – 2012	7 %
202	Head Restraints Front Outboard	1993	1990	1968 – 2012	9 %

202	Head Restraints Front Outboard Upgrade	2010	2009	2009 – 2012	9 %
202	Head Restraints Rear	2010	2011	1992 – 2012	9 %
203/204	Steering Assembly	1969	1980	1970 – 2012	7 %
206	Door locks - Sliding doors on LTVs	1975	2006	1985 – 2012	7 %
208	Lap belts – front seat outboard	1973, with previous estimates in 1968	1970	1972 – 1980	4 %
208	Lap belts – front seat center	1980, with previous estimates in 1968-74	1970	1968 – 2012	4 %
208	Lap belts – rear seat outboard	1980, with both earlier and later estimates	1970	1972 - 1991	4 %
208	Lap belts – rear seat center	1992, with several previous estimates	1970	1968 – 2012	4 %
208	Lap/shoulder – front seat outboard	1989, with several previous estimates	1975	1972 – 2012	4 %
208	Lap/shoulder – rear seat outboard	1990, with previous estimate in 1971	1989	1987 – 2012	4 %
208	Lap/shoulder – rear seat center	1996	2003	1998 – 2012	4 %
208	Air bag - driver	2007	1992	2007 – 2012	7 %
208	Air bag – passenger	2007	1994	2004 – 2012	7 %
208	Pretensioners and load limiters	1999	N. A., all voluntary	1995 – 2012	4 %
208	Adjustable anchors	1999	1994	1990 - 2012	4 %
208	Manual on-off Switch	1998	N. A., all voluntary	1997 – 2012	7 %
214	Side Door Beams	1994	1991	1991 - 2012	7 %
214	Side Air Bags/Window	2001	2005	1996 – 2012	7 %

	Curtains				
225	LATCH - Lower Anchors and Tethers for Children	2012	2001	2001 – 2012	7 %
226	Ejection Mitigation - Rollover Sensor	2005	2011	2002 - 2012	7 %
301	Fuel System Integrity 1976-78	1976	1977	1977 - 2012	7 %
301	Fuel System Integrity - 2007-2009	2005 - 2010	2007	Not Used	N.A.

Notes:

- The third column shows the model year for which the original teardown estimates were developed.
- The fourth column shows the first year costs were attributable to the FMVSS.
- The fifth column shows the years for which the learning curve was applied. In some cases, these years are earlier than the attributable year, because learning was applied to voluntary compliance.

Federal Register Notices reviewed for this analysis

FMVSS No. 103, Windshield defrosting and defogging systems

April 27, 1968, (33 FR 6465), final rule for passenger cars and LTVs. NPRM on December 28, 1967, (32 FR 20865).

FMVSS No. 104, Windshield wiping and washing systems

February 3, 1967, (32 FR 2410) final rule for passenger cars. NPRM on December 3, 1966 (31 FR 15212).

April 27, 1968, (33 FR 6465), extended to LTVs. NPRM on December 28, 1967, (32 FR 20865). Several other standards were covered in the same NPRM and/or final rule, including FMVSS No. 103, 112, 113, 114, 202, 206, 219.

FMVSS No. 105, Braking systems

September 2, 1972, (37 FR 17970) final rule for FMVSS No. 105a for passenger cars and light trucks. NPRM on November 11, 1970, (35 FR 17345) effective September 1, 1974, (subsequently revised).

January 2, 1981 (46 FR 55) There was a requirement for an emergency brake warning switch among other things that was effective for the 1984 make-model LTVs. NPRM was October 18, 1979 (44 FR 60113).

FMVSS No. 108, Side marker lamps

February 3, 1967, (32 FR 2414) Applicable to side marker lamps for both passenger cars and light trucks. NPRM on December 3, 1966 (31 FR 15212).

FMVSS No. 108, CHMSL

October 18, 1983, (48 FR 48235) CHMSL final rule for passenger cars. NPRM on January 8, 1981 at (46 FR 2132)

April 19, 1991, (56 FR 16015) Extending center high mounted stop lamps to light trucks. NPRM on May 31, 1990, (55 FR 22039).

FMVSS No. 112, Headlamp concealment devices

April 27, 1968, (33 FR 6465), final rule for passenger cars and LTVs. NPRM on December 28, 1967, (32 FR 20865). Later added to FMVSS No. 108 and FMVSS No. 112 was reserved.

FMVSS No. 113, Hood latch systems

April 27, 1968, (33 FR 6465), final rule for passenger cars and LTVs. NPRM on December 28, 1967, (32 FR 20865).

FMVSS No. 114, Theft protection and rollaway prevention

March 30, 2010, (79 FR 15621) final rule on transmission shift interlock for passenger cars and LTVs. NPRM on August 25, 2009, (74 FR 42837).

FMVSS No. 118, Power-operated windows

July 23, 1970, (35 FR 11797) final rule for passenger cars and multipurpose passenger vehicles. NPRM on August 23, 1969 (34 FR 13608).

June 24, 1988, (53 FR 23766), final rule extended requirements to LTVS. NPRM on October 16, 1987, (52 FR 38488).

FMVSS No. 124, Accelerator control systems

April 8, 1972, (37 FR 7097) final rule for passenger cars and LTVs. NPRM on September 30, 1970, (35 FR 15241).

FMVSS No. 126, Electronic control systems

On April 6, 2007, (72 FR 17236), NHTSA published in the Federal Register a final rule on FMVSS No. 126 to require ESC on passenger cars and LTVs. NPRM on September 18, 2006 (71 FR 54712).

FMVSS No. 138, Tire pressure monitoring systems

April 8, 2005, (49 FR 18136) final rule for passenger cars and LTVs. NPRM on July 26, 2001, (66 FR 38984).

FMVSS No. 139, New pneumatic radial tires

June 26, 2003, (68 FR 38116) final rule for tire on passenger cars and LTVs. NPRM on March 5, 2002, (67 FR 10050).

FMVSS No. 201, Interior padding

February 3, 1967, (32 FR 2414) Applicable to passenger cars. NPRM on December 3, 1966 (31 FR 15212).

November 29, 1979, (44 FR 68470) final rule extended to LTVs. NPRM on November 9, 1978 (43 FR 52264).

FMVSS No. 201 was substantially upgraded for upper interior head protection in August 1995 (60 FR 43031). The NPRM was published in the Federal Register on February 8, 1993, (58 FR 7506) applicable to passenger cars and LTVs.

FMVSS No. 202, Head restraints

February 14, 1968, (33 FR 2945) final rule for passenger cars. NPRM on December 28, 1967, (32 FR 20865).

September 25, 1989, (54 FR 39183) final rule extending requirements to LTVs. NPRM on December 13, 1988, (53 FR 50047).

December 4, 2004, (69 FR 74848) final rule head restraint upgrade for passenger cars and LTVs. NPRM on January 4, 2001, (66 FR 968).

FMVSS Nos. 203 and 204, Steering column system

February 3, 1967, (32 FR 2414) final rule for passenger cars. NPRM on December 3, 1966 (31 FR 15212).

November 29, 1979, (44 FR 68470) extended final rule to LTVs. NPRM November 9, 1978 (43 FR 52264).

FMVSS No. 205, Glazing materials

February 3, 1967, (32 FR 2410) final rule for passenger cars and LTVs. NPRM on December 3, 1966 (31 FR 15212).

FMVSS No. 206, Door locks

February 3, 1967, (32 FR 2414) final rule for door locks and door retention components for passenger cars. NPRM on December 3, 1966 (31 FR 15212).

September 28, 1995, (60 FR 50124) final rule extending standard to back doors for passenger cars and LTVs. NPRM on August 30, 1994, (59 FR 44691).

February 6, 2007, (72 FR 53385) final rule affecting sliding doors, only affected LTVs. NPRM on December 15, 2004, (69 FR 75020).

FMVSS No. 207, Seating systems

February 3, 1967, (32 FR 2414) final rule for seat back locks, only affected passenger cars. NPRM on December 3, 1966 (31 FR 15212).

FMVSS No. 208, Occupant crash protection

February 3, 1967, (32 FR 2414), required lap belts at all designated seating positions for passenger cars. NPRM on December 3, 1966, (31 FR 15212). This rule also required shoulder belts at the front outboard seats of passenger cars if the lap belts could not keep the dummy from contacting the windshield header in static tests. Since the lap belts could not keep the dummy from contacting the windshield header, this rule in effect required shoulder belts for the front outboard seats of passenger cars effective January 1, 1968.

May 7, 1970, (35 FR 7187), initial NPRM for automatic occupant protection, did not become a final rule.

September 30, 1970, (35 FR 15222), Final rule extending 208 (lap belts at all designated seating positions) to LTVs. NPRM on September 20, 1969 (34 FR 14660).

November 3, 1970, (35 FR 16927) final rule for passenger cars and LTVs to permit automatic occupant protection as one of three ways to comply with FMVSS No. 208. NPRM was published on May 7, 1970, (35 FR 7187).

June 20, 1973, (38 FR 16072), final rule amending FMVSS No. 208 to require integral 3-point belts at front outboard seats in passenger cars. NPRM on April 30, 1973, (38 FR 9830).

July 9, 1975, (40 FR 28805), final rule amending FMVSS No. 208, extending 3-point belts at front outboard seats to LTVs. NPRM on June 3, 1975, (40 FR 23897).

July 5, 1977, (42 FR 34289), final rule requiring automatic occupant protection at front outboard seats in passenger cars. NPRM on June 14, 1976, (41 FR 24070), rescinded in 1981 before its effective date.

July 17, 1984, (49 FR 28962), final rule amending FMVSS No. 208 to require automatic occupant protection at front outboard seats in passenger cars. NPRM on October 14, 1983, (48 FR 48622).

June 14, 1989, (54 FR 25275), final rule amending FMVSS No. 208 to require 3-point belts at the rear outboard seats of passenger cars. NPRM on November 29, 1988, (53 FR 47982).

November 2, 1989, (54 FR 46257), final rule amending FMVSS No. 208 to require 3-point belts at the rear outboard seats of LTVs. NPRM on November 29, 1988, (53 FR 47982).

March 26, 1991, (56 FR 12472), final rule amending FMVSS No. 208 to extend automatic protection to front outboard seats of LTVs. NPRM on January 9, 1990, (55 FR 747).

September 2, 1993, (58 FR 46551), final rule amending FMVSS No. 208 to require manual 3-point belts and dual air bags in front outboard seats in cars and LTVs. NPRM on December 14, 1992 (57 FR 59043).

August 3, 1994, final rule amending FMVSS No. 208 to improve designs for safety belts, including requiring adjustable anchors. April 26, 1994, (59FR 21740), NPRM proposing to amend FMVSS No. 208 to require adjustable anchors.

May 23, 1995, (60 FR 27233), final rule amending FMVSS No. 208 to allow manual on-off switches for passenger air bags in pickup trucks and other vehicles with small or no rear seats. NPRM on October 7, 1994, (59 FR 51158).

May 12, 2000 (65 FR 30679), final rule amending FMVSS No. 208 to require advanced frontal air bags. NPRM was published September 18, 1998, (63 FR 49958)

December 8, 2004, (69 FR 70904), final rule requiring 3-point belts for center rear seats for passenger cars and LTVs. NPRM was published August 6, 2003, (68 FR 46546).

FMVSS No. 212, Windshield mounting

August 16, 1968, (33 FR 11652), final rule establishing FMVSS No. 212 for passenger cars. NPRM was on December 28, 1967, (32 FR 20866).

August 30, 1976, (41 FR 36493) final rule extending standard to LTVs. NPRMs on August 23, 1972, (37 FR 16979) and January 18, 1974, (39 FR 2274).

FMVSS No. 214, Side impact

October 30, 1970, (35 FR 16801), final rule establishing FMVSS No. 214 (side door strength, passenger cars). NPRM on December 11, 1968, (33 FR 18386), first NPRM.

October 30, 1990, (55 FR 45721), final rule upgrading FMVSS No. 214, adding a dynamic side impact test for passenger cars. NPRM on January 27, 1988, (53 FR 2239).

June 14, 1991, (56 FR 27427), final rule extending FMVSS No. 214 side door strength requirement to LTVs. NPRM on December 22, 1989, (54 FR 52826).

July 28, 1995, (60 FR 38749), final rule extending the FMVSS No. 214 dynamic side impact test to LTVs of 6,000 pounds GVWR or less. NPRM on June 15, 1994, (59 FR 30756).

September 11, 2007, (72 FR 51908), final rule adding a pole test to FMVSS No. 214, Side impact protection for passenger cars and LTVs. NPRM published in the Federal Register on May 17, 2004, (69 FR 27990).

FMVSS No. 216, Roof crush

December 8, 1971, (36 FR 23299), final rule establishing FMVSS No. 216 for passenger cars. NPRM on January 6, 1971, (36 FR 166).

April 17, 1991, (56 FR 15510), final rule extending FMVSS No. 216 to LTVs with GVWR of 6,000 pounds or less. NPRM on November 2, 1989, (54 FR 46275).

May 12, 2009, (74 FR 22347), final rule upgrading FMVSS No. 216, Roof crush resistance for passenger cars and LTVs of 10,000 pounds GVWR or less. The NPRM was issued on August 25, 2005, (70 FR 49223).

FMVSS No. 219, Windshield zone intrusion

June 16, 1975, (40 FR 25462) final rule for passenger cars and LTVs. NPRM on May 20, 1974, (39 FR 17768) and August 31, 1972, (37 FR 17763).

FMVSS No. 225, lower anchors and tethers for children - LATCH

March 5, 1999, (64 FR 10786), final rule establishing FMVSS No. 225 for passenger cars and LTVs and amending FMVSS No. 213 to require upper and lower tethers on child safety seats. NPRM on February 20, 1997, (62 FR 7858).

FMVSS No. 226, Ejection mitigation

January 19, 2011, (76 FR 3212) final rule for passenger cars and LTVs. NPRM on December 2, 2009, (74 FR 63180).

FMVSS No. 301, Fuel system integrity

February 3, 1967, (32 FR 2414) final rule on FMVSS No. 301 for passenger cars. NPRM on December 3, 1966 (31 FR 15212).

August 20, 1973, (38 FR 22397), final rule extending the standard to LTVs. NPRM on August 29, 1970, (35 FR 13799).

December 1, 2003, (68 FR 67068), final rule to upgrade the rear- and lateral-impact test procedures of FMVSS No. 301 for passenger cars and LTVs. NPRM on November 13, 2000 (65 FR 67693).

FMVSS No. 401, Interior trunk release

October 20, 2000 (65 FR 63014) final rule only affects passenger cars. NPRM on December 17, 1999, (64 FR 07672).

FMVSS No. 403/404, Platform lifts

December 27, 2002, (67 FR 79416) final rule essentially only affects LTVs. NPRMs were published on July 27, 2000 (65 FR 46228) and February 26, 1993, (58 FR 11562).

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