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

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DOT HS 810 777 **January 2007**

The Impact of Safety Standards and Behavioral Trends on Motor Vehicle Fatality Rates

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT HS 810 777		

4. Title and Subtitle	5. Report Date
The Impact of Safety Standards and Behavioral Trends on Motor Vehicle Fatality Rates	January 2007
	6. Performing Organization Code
7. Author(s) Lawrence Blincoe and Umesh Shankar	8. Performing Organization Report No.
9. Performing Organization Name and Address National Center for Statistics and Analysis National Highway Traffic Safety Administration Washington, DC 20590	10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration 1200 New Jersey Avenue SE. Washington, DC 20590	13. Type of Report and Period Covered NHTSA Technical Report 14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

The National Highway Traffic Safety Administration (NHTSA) is charged with improving the safety of our Nation's roadways. The agency accomplishes this by regulating vehicle safety performance, enforcing existing safety requirements, and promoting programs that influence driver behavior. As a routine part of the agency's planning process, the agency sets goals that reflect its current and future programs. These goals give the agency a focus for setting priorities in its regulatory and behavioral efforts, as well as a basis for measuring the success of these efforts. Typically, the metrics the agency uses to set goals are fatality rates based on exposure to risk. This paper describes the process, assumptions, and methods used by the agency to estimate the impact of its safety regulations and behavioral programs on fatality rates, and measures the impact of these programs on those rates through the year 2020. The study projects an increase in seat belt use rates from 81 percent in 2006 to 94 percent by 2020. This would prevent a growing number of fatalities over this period starting with over 400 additional lives saved in 2007 and increasing to over 3,500 additional lives saved in 2020. Similar savings could come from a continuation of trends in alcohol-involved crashes. Together, these behavioral programs could save over 5,800 additional lives annually by 2020, and reduce the fatality rate by 0.16. Federal requirements for electronic stability control, improved side impact protection, ejection mitigation, and heavy-truck stopping distance will prevent over 3,500 additional fatalities annually by 2020 and reduce the fatality rate by 0.10. If behavioral trends continue, NHTSA's combined program activity, including both motor vehicle safety regulations and behavioral programs, will prevent approximately 1,500 additional fatalities by 2008, and nearly 10,000 additional fatalities by 2020, and reduce the fatality rate by 0.27.

17. Key Words	18. Distribution Statement
fatality rate - trends -accidents - crashes - motorcycle - safety belts - seat belts - alcohol - impaired driving - ESC – electronic stability control – behavioral – FMVSS – motor vehicle – overlap – VMT – highways – roads – safety standards – conversion rate	Document is available to download at www.nhtsa.dot.gov

19. Security Classif.(of this report)	20. Security Classif.(of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified		

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

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Analysis Summary

- Fatality rates were estimated for the period from 2006-2020 based on the projected impact of known safety technologies and behavioral trends.
- The impact of both voluntarily installed and federally mandated safety equipment was estimated by computing the rate of penetration into the on-road vehicle fleet.
- Seat belt use was estimated to increase based on its historical pattern – an annual average conversion rate of 8 percent.
- Alcohol-related fatalities were estimated based on their historical trend.
- Motorcycle fatalities were estimated to follow a cyclical pattern defined by generational influence.
- Adjustments were made for overlap among safety benefits.

Results Summary

- Behavioral programs will have a significant impact on fatality rates. If existing trends in seat belt usage and alcohol-involved fatalities are maintained, fatality rates could be reduced by 0.16 by 2020.
- Electronic Stability Control (ESC) will have a strong and growing impact. By 2020, ESC will be in 60 percent of the on-road fleet and it will be responsible for reducing the fatality rate by 0.08.
- Several other anticipated Federal safety standards with later effective dates – side impact upgrade, ejection mitigation, and heavy-truck stopping distance, will impact the fatality rate by 0.02 in 2020.
- If behavioral trends continue, NHTSA's combined program activity, including both motor vehicle safety regulations and behavioral programs, will reduce the fatality rate by 0.27 by 2020.
- The study projects an increase in seat belt use rates from 81 percent in 2006 to 94 percent by 2020. This would prevent a growing number of fatalities over this period starting with over 400 additional lives saved in 2007 and increasing to over 3,500 additional lives saved in 2020. Similar savings could come from a continuation of trends in alcohol-involved crashes. Together, these behavioral programs could save over 5,800 additional lives annually by 2020.
- Federal requirements for ESC, improved side impact protection, ejection mitigation, and heavy-truck stopping distance will prevent over 3,500 additional fatalities annually by 2020.
- If behavioral trends continue, NHTSA's combined program activity, including both motor vehicle safety regulations and behavioral programs, will prevent approximately 1,500 additional fatalities by 2008, and nearly 10,000 additional fatalities by 2020.

Introduction

The National Highway Traffic Safety Administration (NHTSA) is charged with improving the safety of our Nation's roadways. The agency accomplishes this by regulating vehicle safety performance, enforcing existing safety requirements, and promoting programs that influence driver behavior. As a routine part of the agency's planning process, the agency sets goals that reflect its current and future programs. These goals give the agency a focus for setting priorities in its regulatory and behavioral efforts, as well as a basis for measuring the success of these efforts. Typically, the metrics the agency uses to set goals are fatality rates based on exposure to risk. This paper describes the process, assumptions, and methods used by the agency to estimate the impact of its safety regulations and behavioral programs on fatality rates, and measures the impact of these programs on those rates. Establishing safety goals involves both analytical and policy considerations. The estimates that result from this analysis are intended as guidance for policy makers in establishing safety goals, but the estimates are not, in themselves, recommendations for these goals.

Relevant Factors

Projections of future fatality rates must take into account the normal turnover of vehicles in the on-road fleet that occurs as older vehicles are replaced by newer vehicles with improved safety characteristics. The difference in safety between newer and older fleets will be influenced by a number of factors including both existing and anticipated safety standards as well as voluntary changes that manufacturers make in vehicle designs. Likewise, trends in driver behavior will influence fatality rates. Demographic factors such as population growth and developmental sprawl will also affect safety by increasing the use of motor vehicles. The effects of the following factors were examined for their influence on future fatality rates:

1) Increased penetration of existing safety standards into the on-road passenger vehicle[1] fleet (ORF).
2) New safety standards certain or likely to be established prior to the outside timeline (2020) but not yet effective.
3) Significant safety innovations voluntarily adopted by manufacturers prior to their establishment as Federal Motor Vehicle Safety Standards (FMVSS).
4) Expected increases in seat belt use rates over the examined timeline.
5) Expected decreases in alcohol-involved fatalities over the examined timeline.
6) Expected increases in vehicle miles traveled (VMT) over the examined timeline.

Externalities such as improvements in roadway design, aging of the population, impact on driving from changes in gas prices, changes in the routine habits of people (e.g., increased walking and bicycling), changes in the mix of vehicle types preferred by consumers, increased telecommuting, demographic shifts, unforeseen economic and technological trends, etc., would also have an effect, but are difficult to predict and were not examined in this study.

[1] Passenger vehicles include passenger cars, light trucks, SUVs, and vans less than 10,000 lbs. GVWR.

Approach

The general approach used to estimate future fatality rates consisted of three steps:

1) Established baseline penetration rates and fatality savings for each safety standard or behavioral factor.
2) Projected the increase in ORF penetration of existing and anticipated standards and the resulting change in safety impacts annually throughout the examined time period.
3) For each year, the impact of all safety factors was then summed and adjusted for both increased levels of VMT and overlap with other safety countermeasures. A resulting fatality rate was then computed based on projected fatalities and VMT.

Penetration Rates

For existing safety standards, current penetration rates within the on-road fleet were derived from Kahane's safety standards benefit study.[2] Kahane supplied 2002 baseline data from a separate run of his database. These data are summarized along with independently derived seat belt data and estimates of remaining potential benefits in Table A-1 in Appendix A. The yearly change in ORF penetration was estimated assuming an annual increase of 1.8 percent in the ORF (based on historical trends), and annual passenger vehicle sales of 17 million (also based on recent history). The annual number of vehicles scrapped was imputed to be consistent with these two assumptions as follows:

$$R_n = ORF_{n-1} + N_n - ORF_n$$

Where: R = Estimated vehicles scrapped (retired)
ORF = On-road fleet
N = New vehicle sales
n = Year

Annual penetration rates were computed by adding sales of current model year vehicles containing new safety equipment to the previous year's total ORF while removing older scrapped vehicles. Older vehicles with safety equipment might be assumed to be removed proportionally to the current rate of equipment penetration. However, vehicle retirements are caused by a combination of damage in crashes and the obsolescence that occurs with use as vehicles break down mechanically or physically to the point where repair costs exceed their value to maintain in running condition. Since this latter factor is a function of age, vehicles that are removed from the fleet actually have, on average, a lower penetration rate of safety standards than found in the current calendar year's on-road fleet.

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[2] Kahane, C.J,."Lives Saved by Federal Motor Vehicle Safety Standards and Other Vehicle Safety Technologies, 1960-2002 – Passenger Cars and Light Trucks – With a Review of 19 FMVSS and their Effectiveness in Reducing Fatalities, Injuries, and Crashes", National Highway Traffic Safety Administration, DOT HS 809 833, Washington, DC, October 2004.

Whatever presence safety standards have in the ORF is contained within the most recent model years. To the extent that safety equipment is absent from the ORF, its absence is confined to older vehicles that were built prior to its requirement as a safety standard or development as a voluntary feature. Thus, a very old safety technology such as seat belts may already be in nearly 100 percent of the ORF, whereas a more recent safety technology such as antilock brakes may be in less than a third of the ORF. In this example, the third of the ORF that has the recent technology would be vehicles that represent the youngest third of the ORF, which might include, for example, the most recent five years of new vehicle sales. However, because older vehicles are overrepresented in retirements, vehicles of these same ages do not make up a third of the vehicles that are scrapped.

To address this issue, a relationship was developed between the age of the on-road fleet and the age of vehicles that are scrapped. Age specific survival rates developed by NHTSA[3] were combined with age-specific ORF data[4] to develop profiles of cumulative ORF and scrapped fleet retirements by age. The resulting profiles were then regressed to establish a relationship with cumulative retirements as the dependent variable. A polygonal model with an r^2 of 0.992 was chosen as best fit and produced the following relationship:

$$y = 1.0229x^2 + 0.0233x + .0195$$

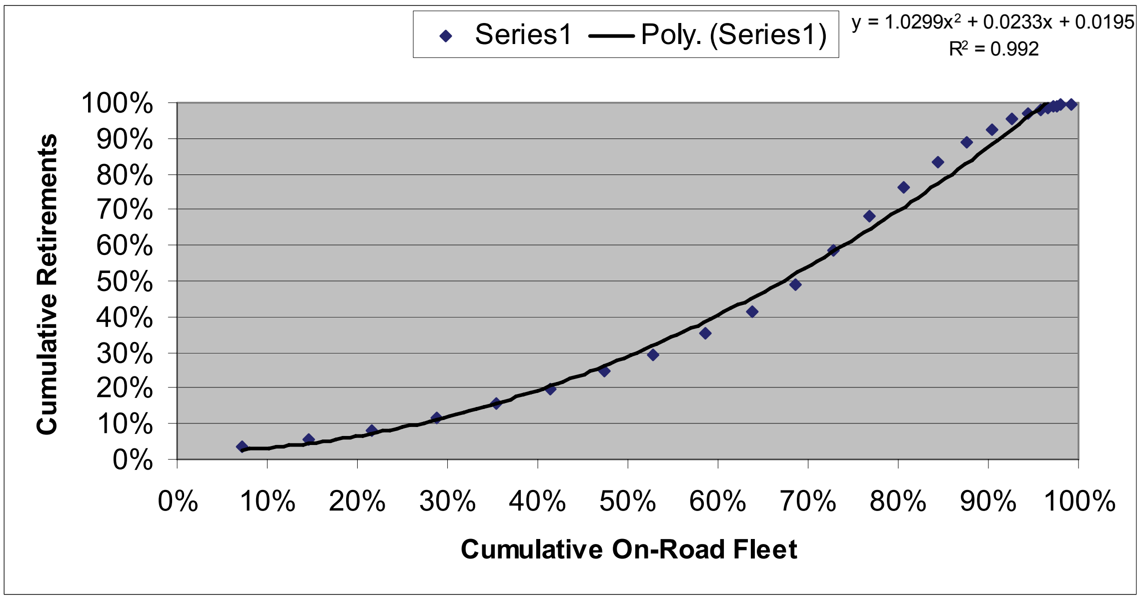
Where: y = Cumulative retirements associated with x
x = Cumulative on road fleet by age

This process is illustrated in Tables A-2, A-3, and A-4 (see Appendix A), and Figure 1 below.

As applied to this analysis, x is equal to the portion of the ORF in each previous (n-1) calendar year that contains each specific standard. The variable y represents the portion of scrapped vehicles from each current (n) calendar year that contains each specific standard.

[3] Lu, S., “Vehicle Survivability and Travel Mileage Schedules, Corrected Document”, National Highway Traffic Safety Administration, DOT HS 809 952, Washington DC, September 2006
[4] R.L. Polk Co.

Figure 1
Relationship Between Vehicle Retirements and Retirements of Vehicles With Safety Standards



For safety equipment required by standards that are not yet effective, as well as for anticipated standards such as Electronic Stability Control, future penetration rates were estimated based on a combination of known voluntary installation rates and proposed or mandated phase-in schedules.

The formula used to estimate each year's on-road fleet penetration for each specific standard is:

$P_{n,s} = (P_{n-1,s} * t_{n-1} + N_n z_{n,s} - r_n * y_{n-1,s}) / (t_{n-1} + N_n - r_n)$

Where: P = Penetration rate in on-road vehicle fleet
n = Calendar year (2003-2020)
s = Specific safety standard
t = On-road passenger vehicle fleet size
N = Annual new passenger vehicle sales
z = Portion of new passenger vehicle sales that have a specific safety feature
r = Annual passenger vehicle retirements
y = Portion of retired fleet that contains specific safety standard

Since P is derived for the purpose of calculating calendar year benefits, an additional adjustment is required to reflect the fact that new vehicle sales and annual scrappage totals are spread throughout the year. Both new sales and scrapped vehicles would accumulate during the year and would not reach their annual totals until the end of the year. Therefore, the full safety impact of these shifts in the fleet composition would not be achieved during the current year. To reflect this, a fleet adjustment factor was added. This factor was set to 0.5 for both new sales and current retirements, reflecting an assumption that, on average, half of the potential annual safety impacts would be achieved during the current year.[5]

The penetration formula modified for average safety impacts in year n would thus be:

$P_{n,s}= (P_{n-1,s}*t_{n-1}+N_n z_{n,s}*L_n – r_n*y_{n-1,s}*L_n)/(t_{n-1}+N_n*L_n-r_n*L_n)$

Where: L_n = 0.5, but P_{n-1} is recalculated with L_n set at 1.0 to reflect end-of-year penetration rates.

Table A-5 (see Appendix A) summarizes the annual ORF penetration rates derived from this analysis.

Projected Incremental Safety Benefits

Using Kahane's 2002 safety benefits and penetration rates as a starting point, full fleet safety benefits at 2002 VMT levels were calculated as follows:

$F_s = f_{b,s}/P_{b,s}$.

Where: F_s = Fatalities prevented by specific standard at full implementation
$f_{b,s}$ = Fatalities prevented by specific standard in base year (2002)
$P_{b,s}$ = Penetration rate for specific safety standard in base year (2002)

The incremental fatalities prevented were then calculated as:

$f_{ns} = F_s*(P_{n,s} – P_{b,s})$

Where: f_{ns} = Incremental fatalities prevented
P_{ns} = Penetration rate of standard s in year n

[5] This assumes an even distribution of both sales and retirements throughout the year, with the proportions increasing from zero at the start of the year to 100 percent at the end of the year.

Vehicle Miles Traveled

The annual increase in VMT was estimated based on the average increase over the most recent 3-year period (2003-2005) or 1.5 percent per year.[6] This factor was applied to both the estimated base fatalities and to the estimated lives saved due to safety standards to reflect the assumption that as travel increases, both potential fatalities and safety benefits increase to reflect the added exposure.

Seat Belts

Future seat belt usage rates were estimated by examining the background trend in observed seat belt use rates after eliminating the data spikes caused by the initial institution of primary belt laws. This produces an estimate of the change in belt use expected based on educational and societal trends, but without specific changes in State laws requiring belt use. Currently there are 25 States that have not passed primary belt laws, and data indicate that passage of such laws, which allow for direct enforcement of seat belt wearing, can increase belt use rates significantly. This constraint may thus produce a conservative estimate of belt use increases in specific years when such laws are passed. The metric used to define change in belt use was conversion rates. Conversion rates measure the portion of seat belt nonusers who are converted to belt users each year. Changes in State observation use rates from 1998 through 2005 were examined after eliminating years in which primary laws became effective. No particular trend in conversion rates was apparent so the annual average rate of 8 percent was used for each year. This produced an estimate of about 94-percent usage by 2020 (up from 81% in 2006 – see Table A-5). Seat belt benefits were calculated directly from projected use rates using procedures previously established within NHTSA.[7]

Alcohol

The change in alcohol-related fatalities was derived from trend data. The reduction in alcohol-related fatalities was established over the timeline based on these historical trends. This assumes a continuation of the trend in improvements in public awareness and enforcement throughout the time period. Overlap between fatalities prevented by alcohol programs and those prevented by safety standards (including increased belt use rates) was assumed to be proportional to the ratio of additional fatalities prevented due to standards to the total projected fatalities prior to adjusting for the impact of standards. In other words, it was assumed that there is an equal probability that a fatality prevented by

[6] The most recent three-year period was chosen over longer periods because VMT increases have been trending downward. The average for 1975-2005 was 2.8 percent. For 1996-2005 the average increase was 2.1 percent. For 2001-2005 the average was 1.7 percent. For 2003-2005 the average was 1.5 percent.

[7] Blincoe, L.J., "Estimating the Benefits of Increased Safety Belt Use", National Highway Traffic Safety Administration, DOT HS 808 133, Washington, DC, June, 1994 and Wang, J-S, and Blincoe, L.J., "Belt Use Regression Model – 2003 Update", National Highway Traffic Safety Administration, DOT HS 809 639, Washington, DC, May 2003.

reduced alcohol consumption would come from a case that would also benefit from added safety standards or a case that would not benefit from these standards. The relative incidence of these two categories of cases would thus determine the level of overlap.

The overlap formula for alcohol benefits is:

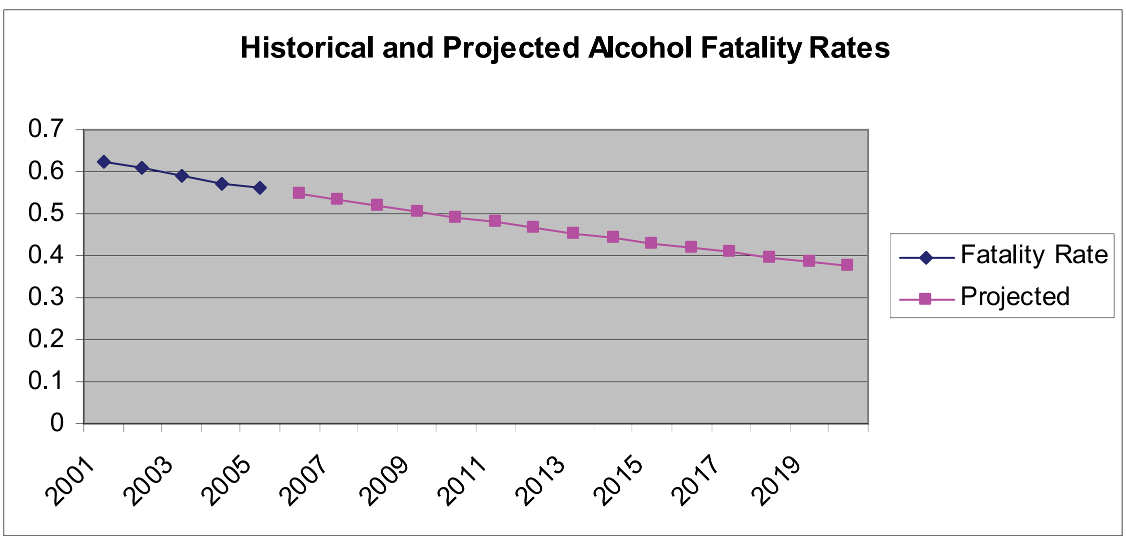
$$OA_n = 1 - \frac{BI_n}{FP_n}$$

$$= 1 - \frac{\sum_{S=1}^{M} f_{n,s}}{FP_n}$$

Where: OA_n = Overlap adjustment factor for alcohol benefits in year n
BI_n = Total incremental benefits (fatalities prevented) in year n adjusted for VMT
FP_n = Predicted total fatalities after adjustment for increased VMT

This formula was applied separately to each calendar year.

Figure 2



Safety Standards Benefits Overlap Adjustment

To account for overlap among numerous safety standards, we calculated the combined net effectiveness of all standards against a broad specified target population (in this case, all fatalities) and compared this to the implied net effectiveness that results from a simple summation of savings from all standards (i.e., the total benefits if there was no overlap among any of the examined standards). A separate overlap factor was calculated for each calendar year. The net effectiveness for each standard was calculated by comparing the added annual savings from that standard (over the base year) to the common potential target population, i.e.:

$e_s = f_{n,s}/BF$

Where e_s = Net effectiveness of specific standard against base target population
$f_{n,s}$= added fatalities prevented by specific standard relative to 2002 base year
BF = Base year (2002) total motor vehicle fatalities (43,005)

The formula for combined effectiveness is:

$$EC_n = 1 - \prod_{S=1}^{M} (1 - e_s)$$

Where EC_n = Combined effectiveness of all standards net of overlap
e_s = Net effectiveness of standard s

The implied effectiveness if there was no overlap among the standards would be:

$$E_n = \sum_{S=1}^{M} \frac{f_{n,s}}{BF}$$

Where E_n = Implied effectiveness of all standards effective in year n based on simple summation of all benefits

An overlap adjustment factor was then calculated as:

$O_n = EC_n/E_n$.

Where O_n = The ratio of effectiveness of combined standards to summed standards.

This factor was then applied to $\sum f_{ns}$ to estimate combined savings net of overlap.

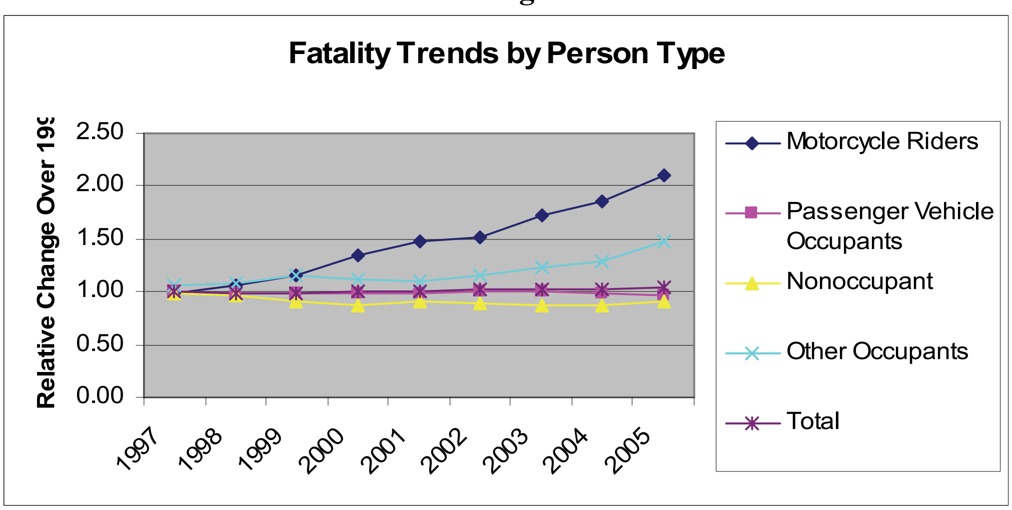
Motorcycles

While significant progress has occurred in preventing fatalities among passenger vehicle occupants, motorcycle fatalities have been rising steadily since the mid-1990s. This trend has been so pronounced that added motorcycle fatalities have essentially offset the impact of higher belt use and improved vehicle safety on passenger vehicle occupants. This has kept the overall motor vehicle fatality total relatively flat with slight increases in the more recent years. Table 1 and Figure 3 illustrate the relative fatality trends in passenger vehicles, nonoccupants, other vehicle occupants, and motorcycles.

Table 1
Motor Vehicle Crash Fatalities by Person Type

	Motorcycle Riders	Passenger Vehicle Occupants	Nonoccupants	Other Occupants	Total
1996	2,161	32,437	6,368	1,099	42,065
1997	2,116	32,448	6,288	1,161	42,013
1998	2,294	31,899	6,119	1,189	41,501
1999	2,483	32,127	5,842	1,265	41,717
2000	2,897	32,225	5,597	1,226	41,945
2001	3,197	32,043	5,756	1,200	42,196
2002	3,270	32,843	5,630	1,262	43,005
2003	3,714	32,271	5,543	1,356	42,884
2004	4,028	31,866	5,532	1,410	42,836
2005	4,553	31,415	5,849	1,626	43,443

Figure 3

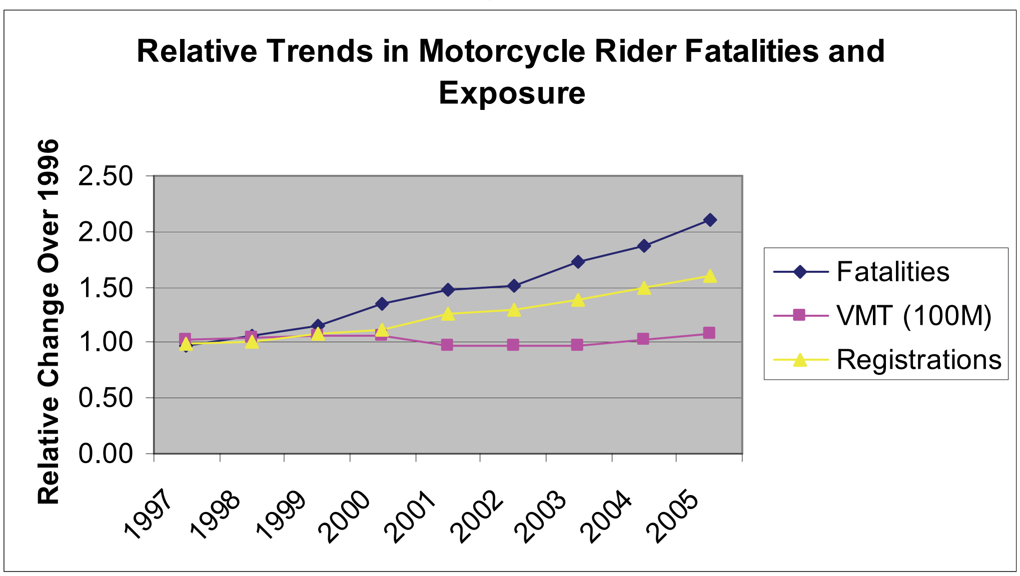


When a sharp increase in motor vehicle fatalities occurs for a specific demographic, it should typically involve either an increase in exposure or a change in behavior. The fatality rate trend for motorcycle riders may involve a combination of these factors. To explore the possible causes of this trend, two different exposure measures - VMT and registrations - were examined. Table 2 and Figure 4 illustrate the trend in motorcycle VMT, registrations, and fatalities.

Table 2
Motorcycle Rider Fatalities, VMT, and Registrations

	Fatalities	VMT (M)	Registrations
1996	2,161	9,920	3,871,599
1997	2,116	10,081	3,826,373
1998	2,294	10,283	3,879,450
1999	2,483	10,584	4,152,433
2000	2,897	10,469	4,346,068
2001	3,197	9,639	4,903,056
2002	3,270	9,552	5,004,156
2003	3,714	9,577	5,370,035
2004	4,028	10,122	5,767,934
2005	4,553	10,770	6,227,146

Figure 4



From Figure 4, it is apparent that the increase in motorcycle fatalities involves more than just exposure. The rate of increase in fatalities is significantly higher than either the increase in registrations or the increase in motorcycle VMT. By 2005, fatalities had more than doubled while registrations rose roughly 50 percent and VMT remained virtually unchanged. VMT is usually considered the best measure for exposure since it measures actual miles traveled. However, given that both fatalities and registrations climbed significantly over this period, the lack of change in VMT does not seem credible. Fatality data is collected through FARS and it represents a complete census of all fatal crashes in the United States. Registration data is collected by the States and provided to the Federal Highway Administration which is responsible for the collection and publication of all exposure data (registration, VMT, licensed drivers). The VMT data collected by the Federal Highway Administration are from estimates gathered by individual States. However, State reporting of motorcycle VMT to FHWA is optional. Even in States that report motorcycle VMT, it is often only measured as a standard proportion of total VMT rather than being collected directly through surveys or roadside counters. FHWA estimates VMT for States that do not report based on data from States that do report. The accuracy of these counts is thus quite speculative. If we accept the fatality and registration counts as reasonably accurate, then there are only two possible explanations for the flat trend in VMT. Either:

1) Existing motorcycle riders are buying additional vehicles while maintaining the registration of their old vehicles, but not increasing their driving and new motorcycle riders are buying vehicles they don't use, or
2) The VMT data are flawed.

Although the first two points need not be absolutes (a mixture of <u>low</u> marginal VMT by existing riders and <u>minimal</u> VMT by new riders is theoretically possible), we believe it is extremely unlikely that a 50-percent increase in registrations would not produce some significant increase in VMT as well. Therefore, for this analysis we have chosen to reject reported VMT as a trend indicator. This leaves registrations as the only viable basis for estimating motorcycle fatality rates.

Estimating the future trend in motorcycle fatalities is problematic. An examination of historical trends back to 1975 indicates that the trend in motorcycle fatalities is highly erratic (see Figure 5). In the late 1970s motorcycles fatalities rose dramatically and remained at a high level for roughly a decade until they began to decline in the late 1980s. In the late 1990s motorcycle fatalities began to climb again. During this roughly 30-year timeframe there is a reasonably strong directional correlation between fatalities and motorcycle registrations. However, as noted above, during the most recent upswing in fatalities, exposure only accounts for a portion of the rise. Another factor may be motorcycle helmet use. NOPUS data indicate that helmet use increased steadily between 1994 and 2000 (climbing from 63% to 71%), but then dropped off sharply in 2001 to 58 percent and continued to decline to the current level of 51 percent. The decline in helmet use corresponded to the most precipitous climb in fatalities during this period.

Another factor that may have contributed to the rise in fatalities is the increase in engine size coupled with an increase in older riders. Table 3 shows that there has been a steady increase in the engine size of motorcycles involved in fatal crashes. Moreover, there has also been a rapid increase in the fatalities among riders ages 40 and older on motorcycles in the 1,001-1,500 cc range. This reflects a growth in the popularity of these large bikes among those in the 40+ age cohort, and particularly within the 50+ age cohort. It appears that much of the upswing in motorcycle sales is driven by middle-aged riders who are either first-time owners or are reacquiring a habit they gave up when they were younger. These heavier and more powerful bikes may be more difficult to control in emergency situations, especially when driven by older riders who are not used to their handling characteristics. Exacerbating this risk is an increased likelihood of riders of larger motorcycles to drive impaired.[8]

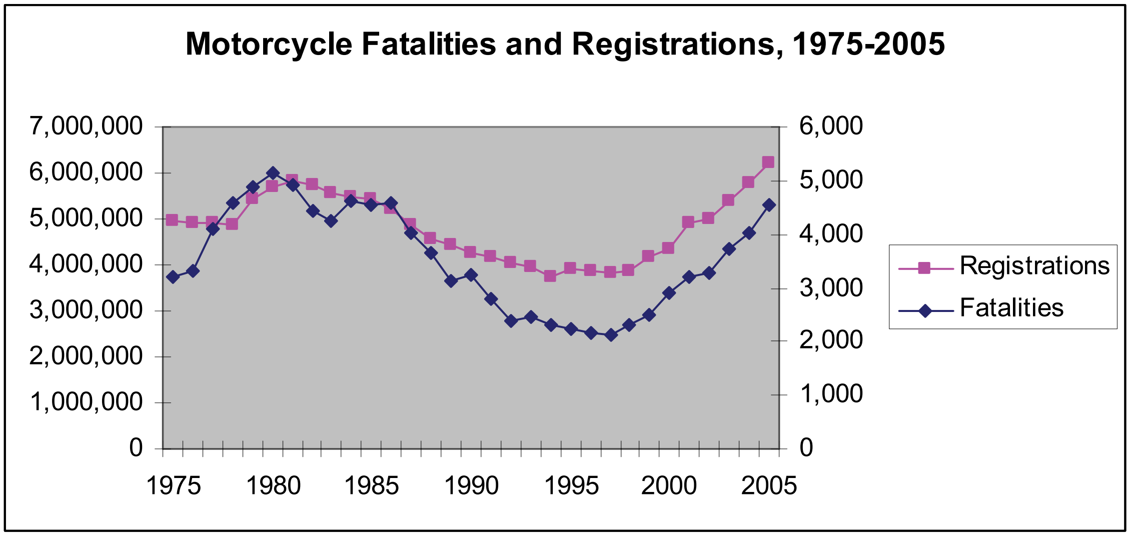
Table 3
Motorcycle Fatality Trends
Age and Engine Size

	Fatalities Mean Age	**Fatal Involved Mean Engine Size (cc)**	**Fatalities 40 and Over**	**Percent of Total 40 and Over**
1996	33.4	866	641	29.7%
1997	34.8	897	699	33.0%
1998	34.6	902	760	33.1%
1999	36.5	927	973	39.2%
2000	36.8	961	1,178	40.7%
2001	36.3	957	1,261	39.4%
2002	37.9	1,002	1,444	44.2%
2003	38.0	1,014	1,694	45.6%
2004	38.0	1,015	1,854	46.0%
2005	38.8	1,018	2,143	47.1%

Thus, it appears that the rapid increase in motorcycle rider fatalities is due to a combination of increased exposure, less experienced riders, more aggressive bikes, and decreased helmet usage. However, it also appears that exposure may be the larger driving factor in this trend.

[8] 2005 FARS data indicate that 32 percent of riders killed on bikes of 1,001-1,500 cc and 27 percent of those killed on bikes with 1,501 cc or larger were impaired. This contrasts with roughly 22 percent on bikes below 1,001 cc.

Figure 5



The largest increase in motorcycle rider fatalities have occurred among older riders (age 40+). This is partially a function of the natural expansion due to aging of the post-war baby boom generation. It's not clear whether this mid-life upswing in motorcycle riding is a characteristic of this specific generation or whether it will continue through succeeding generations. Increases in motorcycle fatalities have been trending up in the 30-39 age cohort as well, though to a lesser extent. It thus appears that there will be some level of continued interest in motorcycle riding among middle-aged riders through the next decade. Moreover, Census Bureau projections indicate that the middle-aged (45-64) population that is fueling the current rise in motorcycle sales will continue to grow through 2020, but that most of the growth will occur by 2010 (see Table 4).

Table 4

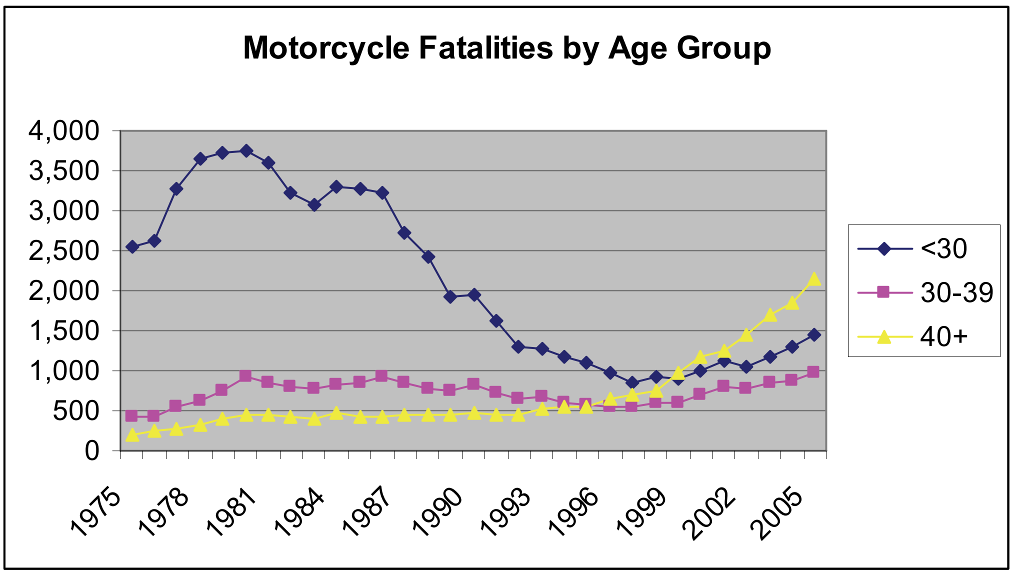
Projected Population of the United States, by Age Group: 2000 to 2050

(In thousands. As of July 1. Resident population.)

Age Group	2000	2010	2020	2030	2040	2050
<5	19,218	21,426	22,932	24,272	26,299	28,080
5-19	61,331	61,810	65,955	70,832	75,326	81,067
Under 20	80,549	83,236	88,887	95,104	101,625	109,147
20-44	104,075	104,444	108,632	114,747	121,659	130,897
45-64	62,440	81,012	83,653	82,280	88,611	93,104
65-84	30,794	34,120	47,363	61,850	64,640	65,844
85+	4,267	6,123	7,269	9,603	15,409	20,861
TOTAL	282,125	308,936	335,805	363,584	391,946	419,854

To explore the issue of generational interest in motorcycles, the historical trend in motorcycle rider fatalities was plotted by age group. Figure 6 indicates that the previous (1977-1987) surge in motorcycle fatalities was driven by riders in the under-30 age category. Riders in this group would now be in the 40+ category, and many would be in the 50+ category – the exact same age group that is driving the current surge in motorcycle registrations[9] and deaths. These data are thus consistent with the concept that a large part – possibly the largest part – of the resurgence in interest in motorcycle riding is caused by a rebirth of interest by baby boomers who rode motorcycles in their 20s, abandoned them for passenger vehicles, and then became interested in them again when they became middle-aged. We cannot verify the extent to which the same individuals are involved, but it does appear to be the same generation that is driving both surges.

Figure 6



Another factor to consider is that abrupt changes in fatality trends that are driven by registrations are unlikely. It takes time for consumers to change their driving habits and after investing in an expensive vehicle they are unlikely to abruptly change "en masse" and stop using it.[10] Once a vehicle becomes part of the on-road fleet, it will likely continue to influence the level of exposure that occurs in motorcycles for the remainder of its useful life. With new registrations putting more bikes on the road and increasing exposure, it is likely to take many years, perhaps a decade, before any reversal occurs in this trend. However, given the role of older riders in the current surge, there is likely to be a natural cessation of this surge at some point due to further aging of the middle-aged

[9] Based on Motorcycle Industry Council statistics.

[10] A sudden shift in gasoline prices might affect driver habits fairly quickly. In this case, higher prices would be likely to accelerate interest in motorcycles because they are fuel efficient relative to other passenger vehicles. However, the current upswing in motorcycle popularity began years before the recent rise in gasoline prices and is likely driven by other factors.

population that is now acquiring these vehicles. Given this perspective, we have modeled the future trend in motorcycle fatalities as a natural cycle based on the trends seen in the historical record. A sine curve was fit to these historical data producing the following relationship:

$a*\sin((y-1974)*\pi/(c/2)) + i$

Where a=1322.081 (S.E. = 72.567)
y = Year
π = 3.14159
c = Cycle length (28 years)
i = Intercept (3480.094) (S.E. = 49.846)

The best fit was provided by a model that assumes a 28-year cycle ($r^2 = .9196$). Figure 7 shows both the historical data and the resulting trend line.

A similar model was fit to the historical trend in registrations. However, the best fit for registrations was derived from a 26-year cycle ($r^2 = .8605$). This produced the following relationship:

$a*\sin((y-1974)*\pi/(c/2)) + i$

Where a = 946958 (S.E. = 69432)
y = Year
π = 3.14159
c = Cycle length (26 years)
i = Intercept (4726478) (S.E. = 48721)

Figure 8 shows both the historical data and the resulting trend line for registrations.

Although both models do a reasonable job of predicting likely trend behavior, there are several problems. The most obvious is that the history based registration model does not predict a steep enough rise for the recent surge in motorcycle registrations. For 2005, the most recent year of available data, the model predicts a registration total 15 percent below the actual level. The fatality model is more accurate, but it underestimates 2005 fatalities by 5 percent. To adjust for this, both models were normalized to 2005 levels. Thus, the breadth and amplitude of the trend cycle predicted by the models is retained, but they are launched from 2005 levels. A second adjustment was required for fatalities to make them consistent with the global assumption of a 1.5-percent annual increase in VMT.[11] To accomplish this, fatalities were assumed to be the larger of the normalized projection or the previous years' normalized projection increased by 1.5 percent. The results from this process were then combined to produce estimates of motorcycle fatalities/1,000 registrations. The results are shown in Figures 9, 10, and 11.

[11] Based on historical VMT data.

Figure 7

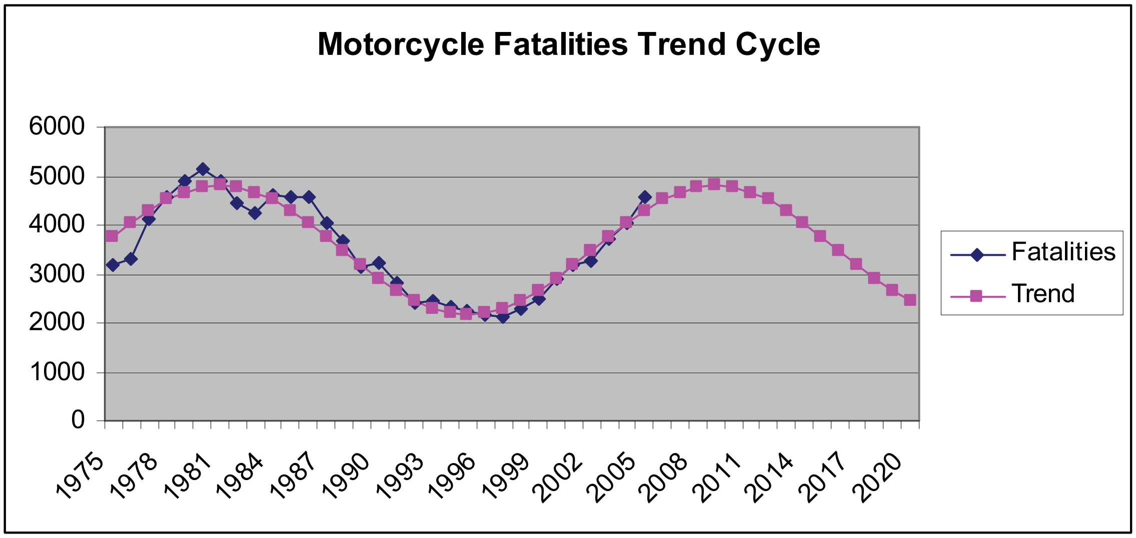


Figure 8

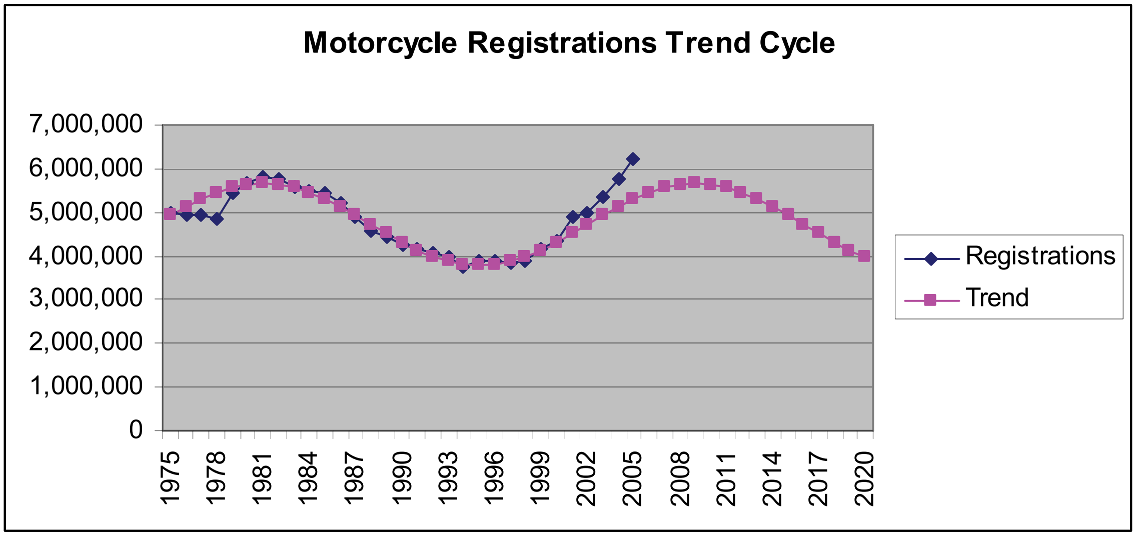


Figure 9

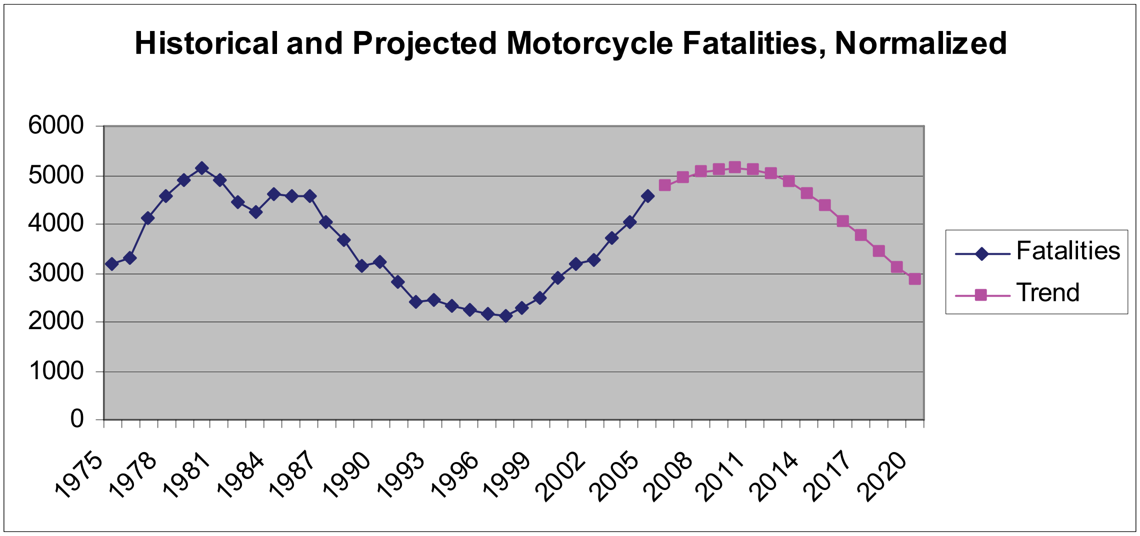


Figure 10

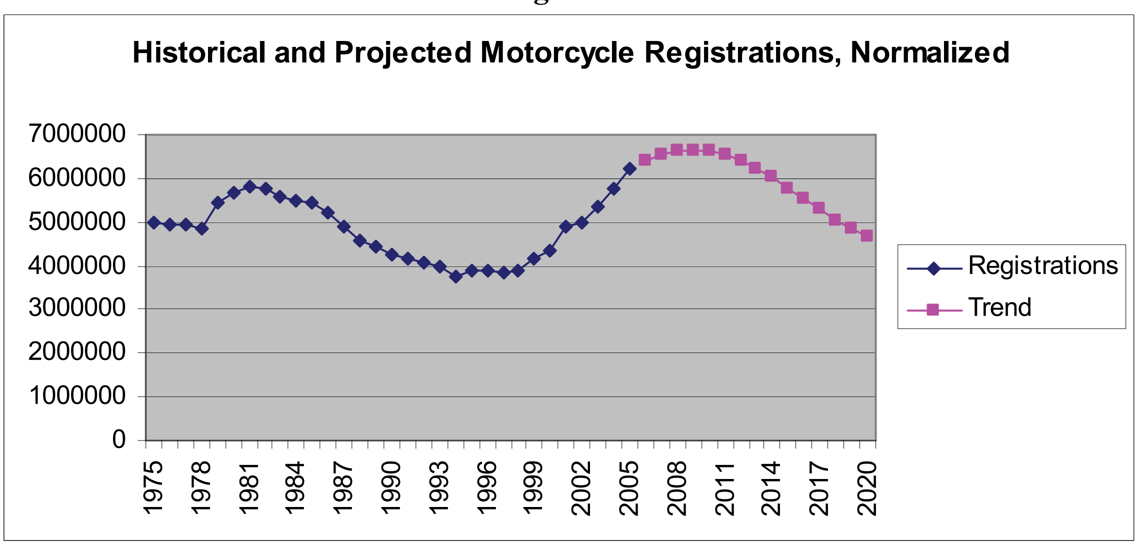
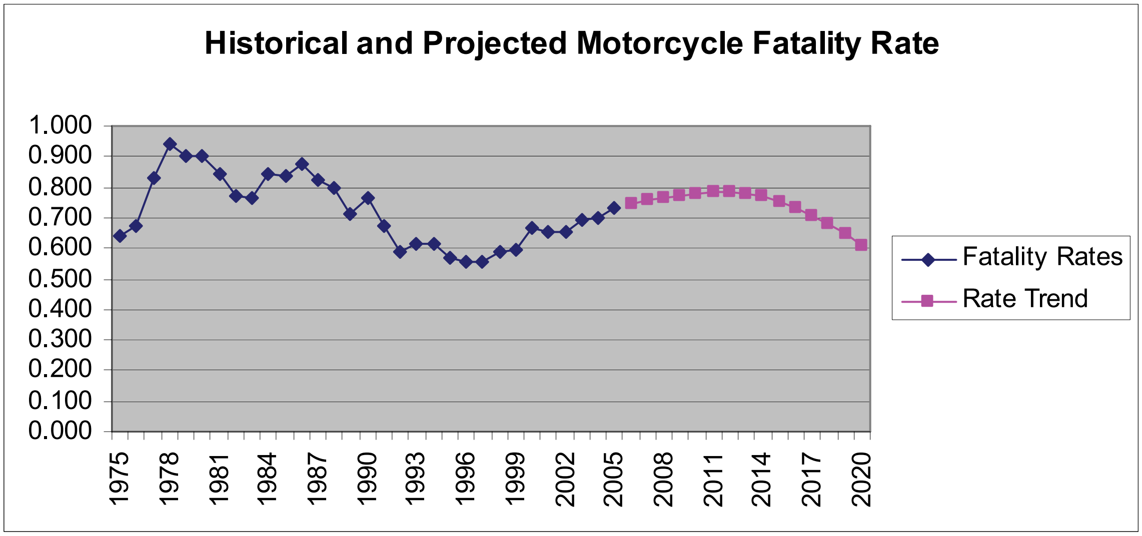


Figure 11



Note that these estimates were not modified to reflect any specific NHTSA safety programs. There are currently no specific new safety standards targeting motorcycles, and Congress has passed legislation preventing the agency from actively promoting motorcycle helmet use, the most effective known protection measure for motorcycle riders. Moreover, while alcohol-involved crashes have declined among other groups, they have actually increased among motorcyclists, reflecting both the higher rates of impaired driving among middle-aged riders and the overall increase in motorcycle rider fatalities. The projected motorcycle fatality rates found in this analysis thus primarily reflect the normal progression of the cycle initiated in the late 1990s.

Results

Projected fatality rates were estimated for five different VMT based metrics: all fatalities, all fatalities excluding motorcycle riders, passenger vehicle[12] occupants, passenger vehicle occupants plus motorcycle riders, and nonoccupants.[13] A separate analysis was also conducted for motorcycles based on registration data rather than VMT (see previous discussion). Table 5 lists the results of these projections for the five VMT based metrics, and Table 6 lists the results for motorcycle riders based on registrations. Figure 12 shows the VMT-based projections together with historical rates. The impact of motorcycles is apparent from these results. When motorcycles are excluded from the overall fatality rate it drops from 1.45 to 1.31 in 2005 and by increasing levels in succeeding years. Likewise, lumping motorcycles in with passenger vehicles increases the 2005 rate from

[12] Passenger vehicles include passenger cars, pickup trucks, vans, and SUVs. It excludes motorcycles, heavy trucks (over 10,000 lbs. GVWR), bicycles, and pedestrians.
[13] Includes pedestrians and bicyclists.

1.14 to 1.30. This reflects the upward trend in motorcycle fatalities which have been rising rapidly, while other fatality categories have been declining. This trend is reflected in the rise in motorcycle sales and registrations, which is apparently fueled by their increased popularity among middle-aged riders.

The target years for agency goals will naturally shift over time, but currently the agency is examining goals for the years 2008, 2011, 2016, and 2020. Under the assumptions used in this analysis, by 2008, the overall fatality rate would decline to 1.37, with further declines to 1.27 in 2011, 1.10 in 2016, and 1.01 by 2020. Similar declines occur for the other passenger-vehicle-related metrics. However, the nonoccupant rate declines much more gradually. This reflects the more significant impact that safety standards have on vehicle occupants – a natural outgrowth of safety standards designed primarily to protect vehicle occupants. Alcohol programs are the primary influence on reduction in nonoccupant fatality rates.

Figure 13 shows the historical and projected fatality rates for the four separate component metrics – all fatalities, passenger vehicles, nonoccupants, and motorcycles – that are examined in this study.

Table 5
Projected Fatalities, VMT (M), and Fatality Rates, 2005-2020

	All Fatalities			All Fatalities Excluding Motorcycles			Passenger Vehicles Only			Passenger Vehicle and Motorcycles			Nonoccupants		
Year	**Fatals**	**VMT**	**Rate**	**Fatals**	**VMT**	**Rate**	**Fatals**	**VMT**	**Rate**	**Fatals**	**VMT**	**Rate**	**Fatals**	**VMT**	**Rate**
2005	43443	2989807	1.45	38890	2979037	1.31	31415	2749555	1.14	35968	2760325	1.30	5849	2989807	0.20
2006	43751	3034654	1.44	38977	3023723	1.29	31441	2790798	1.13	36215	2801730	1.29	5893	3034654	0.19
2007	43363	3080174	1.41	38422	3069078	1.25	30813	2832660	1.09	35754	2843756	1.26	5953	3080174	0.19
2008	42897	3126377	1.37	37852	3115115	1.22	30169	2875150	1.05	35213	2886412	1.22	6015	3126377	0.19
2009	42410	3173272	1.34	37290	3161841	1.18	29528	2918277	1.01	34648	2929708	1.18	6079	3173272	0.19
2010	41945	3220871	1.30	36789	3209269	1.15	28905	2962052	0.98	34061	2973654	1.15	6144	3220871	0.19
2011	41383	3269184	1.27	36263	3257408	1.11	28182	3006482	0.94	33302	3018259	1.10	6211	3269184	0.19
2012	40827	3318222	1.23	35812	3306269	1.08	27459	3051580	0.90	32474	3063533	1.06	6280	3318222	0.19
2013	40297	3367995	1.20	35451	3355863	1.06	26759	3097353	0.86	31605	3109486	1.02	6351	3367995	0.19
2014	39784	3418515	1.16	35163	3406201	1.03	26071	3143814	0.83	30693	3156128	0.97	6423	3418515	0.19
2015	39306	3469793	1.13	34954	3457294	1.01	25414	3190971	0.80	29766	3203470	0.93	6497	3469793	0.19
2016	38900	3521840	1.10	34848	3509153	0.99	24824	3238835	0.77	28876	3251522	0.89	6573	3521840	0.19
2017	38561	3574668	1.08	34825	3561791	0.98	24297	3287418	0.74	28034	3300295	0.85	6651	3574668	0.19
2018	38285	3628288	1.06	34865	3615218	0.96	23829	3336729	0.71	27250	3349799	0.81	6730	3628288	0.19
2019	38068	3682712	1.03	34947	3669446	0.95	23416	3386780	0.69	26536	3400046	0.78	6812	3682712	0.18
2020	37906	3737953	1.01	35054	3724488	0.94	23053	3437582	0.67	25905	3451047	0.75	6895	3737953	0.18

Table 6

Projected Motorcycle Fatalities, Registrations, and Fatality Rates/1,000 Registrations

	Fatalities	Registrations	Fatality Rate /1,000 Regis.
2005	4,553	6,227,146	0.731
2006	4,774	6,402,760	0.746
2007	4,941	6,534,894	0.756
2008	5,044	6,616,922	0.762
2009	5,120	6,644,730	0.771
2010	5,156	6,616,925	0.779
2011	5,120	6,534,900	0.784
2012	5,015	6,402,769	0.783
2013	4,846	6,227,158	0.778
2014	4,621	6,016,871	0.768
2015	4,352	5,782,454	0.753
2016	4,052	5,535,661	0.732
2017	3,736	5,288,868	0.706
2018	3,420	5,054,450	0.677
2019	3,120	4,844,161	0.644
2020	2,851	4,668,547	0.611

Figure 12

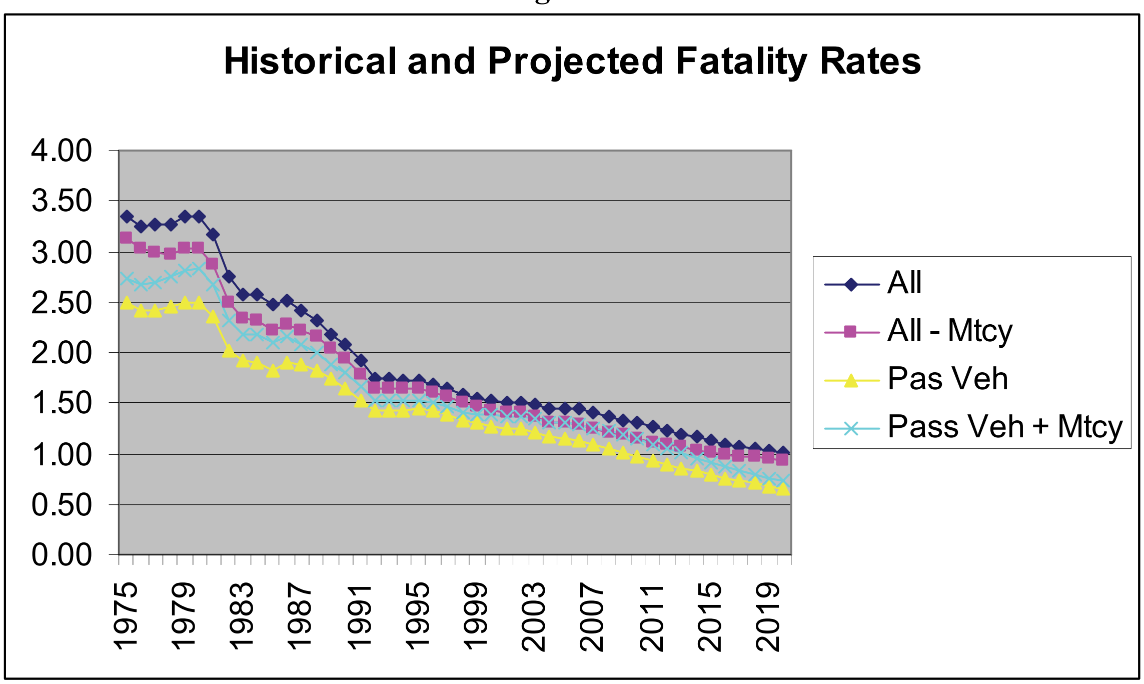
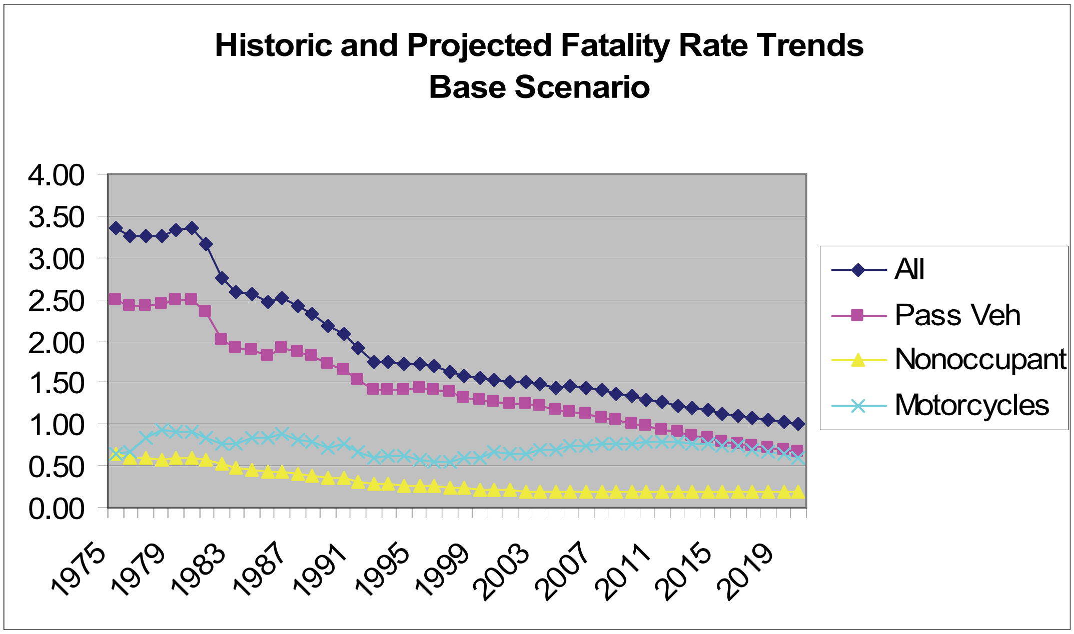


Figure 13



Influence of Safety Countermeasures

Projecting future fatality rates involves taking into account the changing influence of existing standards and making assumptions about future trends. By contrast, adopting a goal implies setting a target that will be achieved with additional action. Since these projections are intended as tools in setting agency goals, it is useful to consider the extent to which they reflect existing and future agency activities. The projected rates reflect the natural progression of existing standards into the on-road fleet as well as anticipated safety standards and voluntary changes that manufacturers are making in vehicle designs. They also assume a continuation of past trends in seat belt use and alcohol-involved crashes. The following future agency actions are thus anticipated in these projections:

1) The promulgation of four significant safety standards, three of which the agency has issued a Notice of Proposed Rulemaking (NPRM), but has not yet issued a final rule. These include: FMVSS No.121 Heavy Truck Stopping Distance, FMVSS No.214 Side Impact Pole Test, and FMVSS No.126 Electronic Stability Control. In addition, it assumes the promulgation of a safety standard covering ejection mitigation. Although the agency has conducted considerable research, it has not yet issued an NPRM for this standard.
2) A level of agency effort necessary to sustain the historical rate of change in the seat belt conversion rate. Over the last decade the agency has made seat belt use one of its top priorities and has invested considerable resources in promoting both primary use laws and educational programs to increase voluntary levels of belt use. At current high use levels (81% nationwide), additional improvements will become increasingly difficult because the remaining nonusers include those most resistant to belt use. Thus, although the pool of nonusers has declined to roughly

19 percent of drivers, sustaining the historical rate of user conversion will require considerable effort.

3) A level of agency effort necessary to sustain the historical downward trend in alcohol-related fatality rates.[14] Again, the self-selection of those most resistant to giving up drinking and driving implies that this will require considerable effort by the agency to maintain the downward trend in alcohol involvement.

Thus, the above projections already anticipate a considerable level of effort by the agency, through both its rulemaking and its behavioral activities. Selection of goals that exceed the timeframes noted in Table 5 would imply an increase in agency activity beyond that noted above. To move the overall fatality rate by a tenth of a point would require preventing approximately 3,000 additional fatalities at current fatality and VMT levels and historically only a handful of agency actions (seat belts and ESC) have had that potential. To move the rate by a hundredth of a point would require the prevention of 300 additional fatalities. It would thus require a highly ambitious program to reach goals that exceed the levels presented in Table 5.

To evaluate the impact of each NHTSA program on fatality rates, future changes in specific programs were eliminated (i.e., the programs' impacts were held constant at current (2006) rates through future years). Under this approach, only demographic factors (as proxied by VMT) and normal safety equipment replacement at current levels would influence future fatality counts. So, for example, installation rates for Electronic Stability Control would be held to their rate in the 2006 new vehicle fleet in future model years as well. The on-road fleet installation percentage would continue to climb due to normal vehicle replacement, but not as swiftly as it would had the new fleet installation rates continued to climb to meet a 100-percent installation rate required by Federal Standard. Likewise, seat belt use rates would be held constant at their 2006 rate, rather than allowing them to increase over time.

Impacts were examined for the following categories:

New Safety Regulations (FMVSS Nos.121, 126, 214, and Ejection Mitigation)
FMVSS No.121
FMVSS No.126
FMVSS No.214
Ejection Mitigation
Behavioral Programs (seat belt use and alcohol)
Seat Belt Use
Alcohol Programs
All NHTSA Initiatives

Tables B -1 and B-2 (see Appendix B) list the results of this analysis for the All Fatalities rate. For each initiative, future impacts were removed while all other impacts were left in place. Thus, the fatality rate that results under each initiative category is the rate that

[14] Based on the change in alcohol-related fatality rates from 2000-2004. During this timeframe, alcohol-related fatality rates declined by an average of .01/year.

would result if the future improvement in that particular initiative were not achieved, while all other initiatives were achieved.

The results in Tables B-1 and B-2 indicate that behavioral programs have significant impacts on the fatality rate in both short- and long-term timeframes. Failure to maintain trends in seat belt use rates would begin to impact the fatality rate immediately in 2007. In 2008 it would raise the rate by .03. By 2011 it would impact the rate enough to increase the fatality rate by .05. By 2016 the rate would rise by .08 and the impact reaches a full tenth point in 2020. Maintaining the status quo on alcohol-involved crashes would also have an aggressive impact on the fatality rate, causing it to increase by .02 by 2008 and .03 by 2011. Through 2020 the impact of not maintaining the rate of decrease in alcohol-involved fatalities increases steadily to .05 in 2016 through 2020. When these two behavioral impacts are combined, the impact is significant, especially in the latter years. Rates rise by .05, .09, and .13 in 2008, 2011, and 2016 respectively. By 2020, failure to show improvement in both seat belt use and drunk driving would increase the fatality rate by .16.

These tables also show significant impacts for the ESC standard. ESC improves the overall fatality rate by .01 by 2010 and progressively increases its impact through 2020 to .08. The other three standards all make gradual contributions, but they do not by themselves have enough impact to move the published fatality rate until the 2017-2020 period. This is primarily due to the projected lead time involved before these standards become effective. Based on NHTSA's NPRMs, ESC installation rates were estimated to be affected by a Federal requirement starting in 2008, whereas side impact standards and ejection mitigation were estimated to be impacted in 2013. Heavy-truck stopping-distance improvements are expected to be required in 2010, but this standard also has a relatively low safety impact compare to the other three standards examined here. When combined, these four standards impact the overall fatality rate in the out years by 0.10 or one tenth – identical to the potential impact from seat belt improvements for that timeframe.

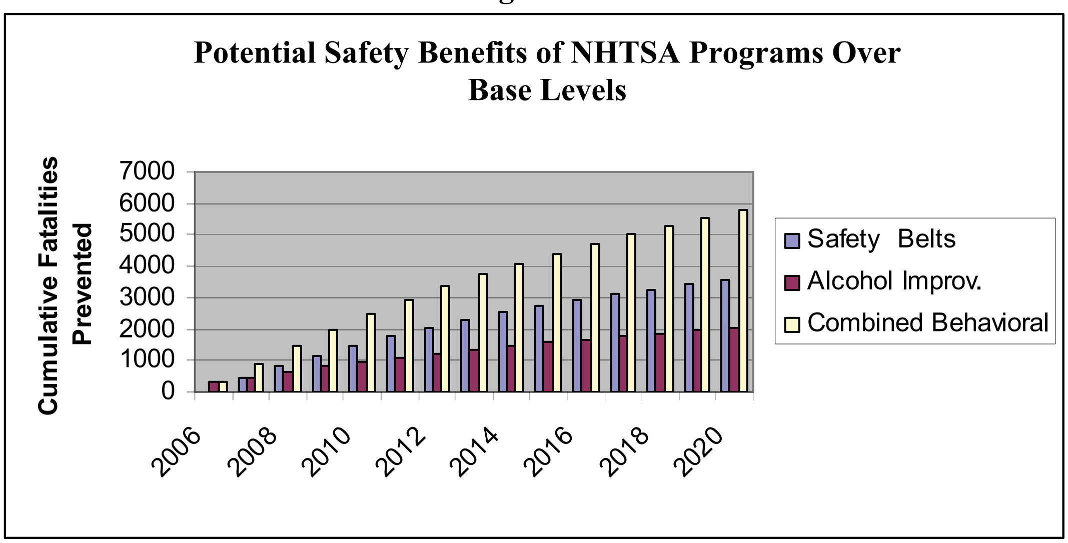
When all future NHTSA activities are removed (i.e., both behavioral and regulatory impacts are held at current levels), the impacts are quite significant. The fatality rate rises rapidly by .05 in 2008, and continues to rise through 2020 to a level that is .27 higher than it would be with NHTSA standards and programs.

Tables C-1 through F-2 (Appendix B) show the results for each of the other metrics examined in this study. These tables show impacts from NHTSA activities similar to those found for the All Fatalities metric.

Fatality Impacts

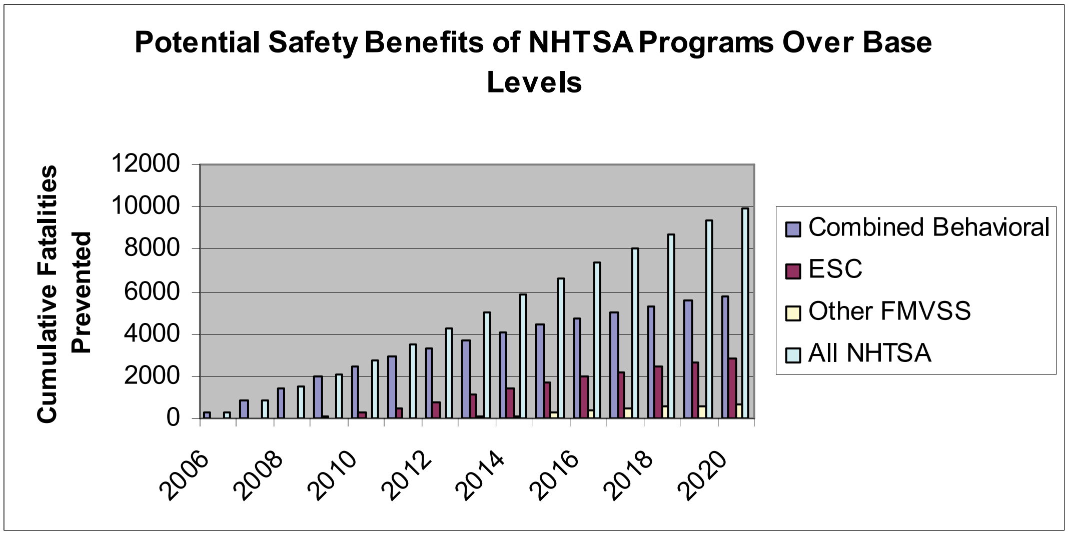
Although the purpose of this study is to examine trends in fatality rates, trends in total fatalities are a natural product of this investigation. Tables G-1 through K-2 (Appendix B) illustrate the fatality impacts of the safety standards and behavioral programs examined in this study. Improving seat belt use has the largest potential to prevent fatalities. The projected growth in belt use from 81 percent to 94 percent by 2020, would save over 400 lives in 2007 and increase steadily to a savings of over 3,500 lives in 2020. A continued reduction in alcohol-involved crashes also offers significant savings throughout this timeframe. Both programs combined could save over 5,800 lives by 2020. Promulgation of a standard requiring ESC in all light vehicles would began to save a small number of lives in 2008, but would rapidly decrease fatalities as new ESC-equipped vehicles enter the fleet. By 2020, an ESC standard could save over 2,800 lives annually.[15] As with fatality rates, the other three standards have less potential during this timeframe due to their later effective dates. When combined together, these four standards would prevent over 3,500 fatalities by 2020. When all NHTSA activity is combined, nearly 1,500 fatalities are prevented annually by 2008, and these savings accelerate to a level of nearly 10,000 by 2020. These impacts are illustrated in Figures 14 and 15.

Figure 14



[15] Note that this represents the difference between the full fleet ESC installation required in NHTSA's proposed safety standard and installation in 42 percent of the new vehicle fleet – the current estimate of pre-standard voluntary installation. Under the agency's proposed standard, 100 percent of the new vehicle fleet will have ESC in 2012 and roughly 60 percent of the on-road fleet will have it by 2020, resulting in the prevention of 6,000 fatalities by this technology.

Figure 15



Sensitivity Analysis

The base scenario used in the above analysis assumes that efforts by the agency and other outside organizations to improve driver behavior will continue to impact safety at the same pace as has been achieved historically. This means that seat belt nonuse will continue to be converted to active use and alcohol-involved fatalities will continue to decline at the same rate that has been observed in the past. While these scenarios are technically achievable, the agency faces an increasingly difficult challenge in maintaining historical rates of progress. As the pool of unbelted and inebriated drivers shrinks, those remaining are typically the least risk-averse and most difficult to influence through either educational programs or legal sanctions.[16]

A further threat to the pace of improvement estimated in the base scenario is uncertainty over the impact of motorcycle fatalities. Data indicate that the primary cause for the recent surge in motorcycle fatalities is increased ridership by middle-aged drivers, especially those in their 50s. As such, there should be a natural decline in motorcycle fatalities as these riders age and reduce their on-road motorcycle exposure or abandon riding altogether. However, data also indicate a small upswing in fatalities among younger riders, and other factors such as oil price instability could cause additional interest in motorcycles and a corresponding upswing in motorcycle fatalities.

[16] After steadily increasing for over a decade, seat belt use declined from 82 percent to 81 percent in 2006.

The base scenario used in this analysis might thus prove to be optimistic. To explore the impact of these assumptions, alternative scenarios were examined in which more pessimistic assumptions were adopted.

Six different alternative scenarios were examined:

1) Modest Seat Belt Progress scenario in which it is assumed that seat belt use increases at half the rate seen historically (i.e., a conversion rate of 4% instead of 8%).
2) Modest Alcohol Improvement scenario in which it is assumed that there is continued progress at half the historical pace for alcohol-related fatality reduction.
3) Modest Behavioral scenario in which both seat belt use and alcohol involvement in fatalities are assumed to progress at half their historical rate.
4) Continuous Motorcycle Rider Fatality Increase scenario in which it is assumed that motorcycle rider fatalities will increase at the same pace as seen over the past eight years.
5) Trend Average Motorcycle Rider Fatality scenario in which motorcycle rider fatalities are assumed to follow a trend midway between the generational trend used in the base scenario and the continuous increase predicted using the Continuous Motorcycle Rider Fatality Increase scenario.
6) Reasonable Worst Case scenario which combines the assumptions of the Modest Behavioral and Trend Average Motorcycle scenarios. Although a combination using the Continuous Motorcycle Increase scenario would actually be worse, we do not consider such a scenario to be probable.

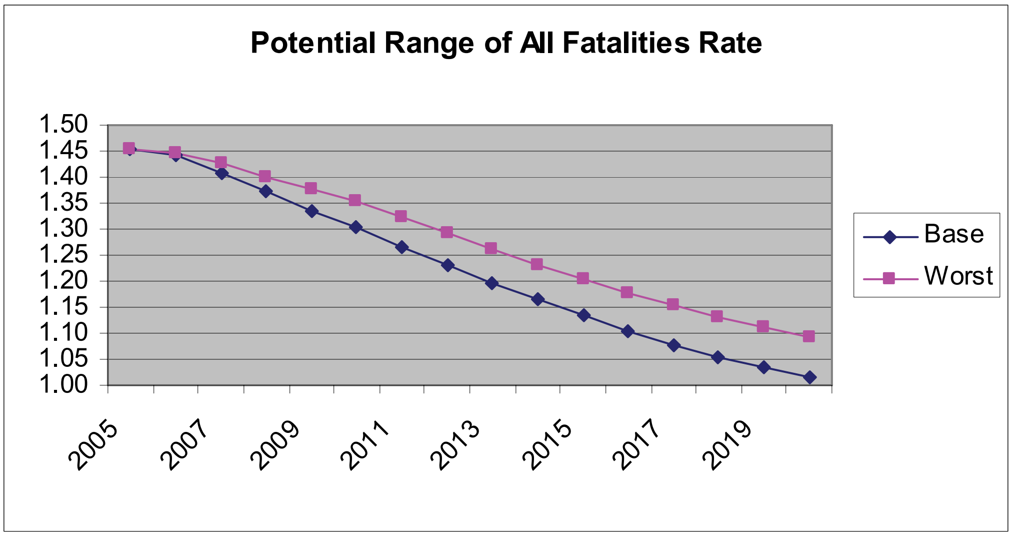
The agency is proposing to set fatality rate goals for four specific measures – all fatalities, passenger vehicles, nonoccupants, and motorcycle riders. Separate goals will be set for the years 2008, 2011, 2016, and 2020. The results of these alternative scenarios are summarized for these years in Table 7. Detailed results for all years from 2005 through 2020 are contained in Tables L-1 through L-7 in Appendix B. Figure 16 illustrates the gap between the base case and the reasonable worst case for the All Fatalities measure.

The results indicate that there are relatively small potential differences in the early goal years, but that differences become more pronounced in the later years. For the all fatalities measure, there is potentially a .03 shift in the predicted rate for 2008. By 2020, this shift has grown to .08. Similar proportions can be observed in other measures. The most dramatic potential shift occurs for motorcycle riders. Although there is very little difference predicted in earlier years, by 2020 the gap between the base case and the reasonable worst case grows to .17. These results indicate that future fatality rates will be highly influenced by the success of the agency's efforts to positively influence driver behavior, but will also be substantially influenced by market choices that are outside the agency's control.

Table 7

		Summary of Alternate Scenario Fatality Rate Estimates					
	Base	Modest Seat Belt	Modest Alcohol	Modest Behavioral	Continuous Motorcycle	Average Motorcycle	Reasonable Worst Case
All Fatalities							
2005	1.45	1.45	1.45	1.45	1.45	1.45	1.45
2008	1.37	1.38	1.38	1.40	1.39	1.38	1.40
2011	1.27	1.29	1.28	1.31	1.30	1.28	1.32
2016	1.10	1.14	1.13	1.16	1.16	1.12	1.18
2020	1.01	1.05	1.04	1.08	1.09	1.03	1.09
Passenger Vehicles							
2005	1.14	1.14	1.14	1.14	1.14	1.14	1.14
2008	1.05	1.06	1.06	1.07	1.05	1.05	1.07
2011	0.94	0.96	0.95	0.98	0.94	0.94	0.98
2016	0.77	0.80	0.79	0.83	0.77	0.77	0.83
2020	0.67	0.71	0.70	0.74	0.67	0.67	0.74
Nonoccupants							
2005	0.20	0.20	0.20	0.20	0.20	0.20	0.20
2008	0.19	0.19	0.19	0.19	0.19	0.19	0.19
2011	0.19	0.19	0.19	0.19	0.19	0.19	0.19
2016	0.19	0.19	0.19	0.19	0.19	0.19	0.19
2020	0.18	0.18	0.19	0.19	0.18	0.18	0.19
Motorcycles							
2005	0.73	0.73	0.73	0.73	0.73	0.73	0.73
2008	0.76	0.76	0.76	0.76	0.77	0.76	0.76
2011	0.78	0.78	0.78	0.78	0.80	0.79	0.79
2016	0.73	0.73	0.73	0.73	0.83	0.79	0.79
2020	0.61	0.61	0.61	0.61	0.85	0.78	0.78

Figure 16



<u>Discussion</u>

Projecting fatality rates into the future is an undertaking that is fraught with uncertainty. The results of this analysis are dependent on a series of assumptions and previous evaluations, each of which has its own level of uncertainty. The safety benefits associated with each of the 21 standards examined here were all derived statistically and thus have some level of uncertainty, both individually and in combination. The many assumptions adopted for this analysis, while based on historical data, are dependent on the continuation of both individual and market place behavior. As such, this type of analysis cannot account for shifts in behavior that inevitably occur over time due to unforeseen economic or social influences. The middle-east, which is the primary source of the world's oil reserves, has never been more volatile, and instability in oil prices can lead to changes in consumer behavior that transform the nature of the vehicle fleet and with it, its safety characteristics.

Exposure is a critical metric in estimating future fatalities. This analysis assumes a continuation of current trends in both the level of driving exposure and the type of exposure. By 2020 this assumption by itself leads to an estimated increase in potentially fatal crashes of over 30 percent. If society accelerates or slows this trend, or if it begins to shift its exposure to either more or less risky roadways, future fatality rates may not match the levels predicted here. The relatively smooth declines in fatality rates predicted for the future in Figure 12, while consistent with the trends found in most recent years, are in stark contrast with stair-step declines that were experienced in earlier decades. To some extent this reflects the initial applications of technologies that are now taken for granted such as air bags and seat belts, but it also reflects significant transformations in vehicle design and size, and shifts in economic or social conditions which influence driving behavior. The trends predicted in this analysis are likely to be punctuated by similar unexpected shifts in driver behavior. This would cause short-term deviations away from the predicted trend line. However, over time, the downward trend in fatality rates should continue as the fleet becomes more saturated with vehicles containing better occupant protection and crash-avoidance safety equipment.

We can foresee several possible scenarios that might confound this trend and cause notable deviations from these predictions. The first would be if the current trend in motorcycle fatalities continues to rise at its current pace for an indefinite period. If interest in motorcycles continues to grow indefinitely rather than curtailing over a 26-28 year generational cycle, it could cause a significant increase in fatalities during the later years covered by this analysis.[17] An even greater impact would occur if improvements in seat belt usage were to stall out at current levels. Improvements in seat belt usage account for over 40-percent of fatality reduction in the earlier years to roughly 30 percent in the later years. The agency and the greater safety community face ever increasing challenges in their efforts to improve seat belt use because current non-users are the least risk-adverse drivers. A similar challenge will occur for programs aimed at reducing impaired driving, which account for 10-15 percent of projected safety benefits.

The technological safety improvements that are soon to be required, or that are already being incorporated into the on-road vehicle fleet through both regulation and voluntary installation, assure that significant progress will be made against motor vehicle fatalities and injuries over the next decade. However, the full potential for safety improvement cannot be realized without continued progress in efforts to improve driver behavior.

[17] For example, if we assume a constant increase in motorcycle fatalities equal to the latest eight-year average increase (+ 305 per year), the overall fatality rate would begin to rise in 2008 by .02 and would be .07 higher by 2020. Given the past volatility of motorcycle fatality trends, at least temporary spikes in motorcycle fatalities that are off the predicted trend are likely to occur.

Appendix A – Data Inputs and Penetration Estimates

Table A-1
Baseline Parameters for Safety Standard Fleet Penetration

FMVSS		**Full Fleet Savings**	**2002 On-Road Fleet %**	**2002 Savings**	**Total Remaining Additional Savings**
105	Dual Master Cylinders	270	99.80%	269	1
105	Front Disc Brakes	271	99.40%	269	2
201	Instrument Panel Padding	935	99.51%	930	5
203/204	Energy Absorbing Steering Columns	2,682	99.05%	2,657	25
206	Improved Door Locks	1,401	99.80%	1,398	3
208	Driver Frontal Air Bags	3,227	63.57%	2,051	1,176
208	Passenger Frontal Air Bags	821	51.41%	422	399
212	Windshield Adhesive Bonding	353	98.41%	347	6
214	Side Door Beams	689	92.10%	635	54
214	TTI Reduction (Already PC&LTV)	1,143	59.40%	679	464
214	Side Air Bags - Torso (PC&LTV)	896	5.50%	49	846
214	Side Air Bags - Head (PC&LTV)	896	2.60%	23	872
216	Roof Crush Strength (PC Only)	162	99.30%	161	1
126	Electronic Stability Control *	10,000	1.50%	150	9,850
105/121	Medium/Heavy Truck ABS	416	49.22%	205	211
201	Upper Interior Head Impact Protection	959	7.90%	76	883
138	TPMS	120	0.00%	0	120
214	Side Impact Upgrade *	1,791	2.15%	38	1,753
NA	Ejection Mitigation *	1,000	0.00%	0	1,000
121	Heavy Truck Stopping Distance *	180	0.00%	0	180
208	Seat Belts	21,724	75.00%	14,178	7,546

Table A-2
Annual On-Road Fleet Penetration for Existing and Proposed Safety Standards

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
105	Dual Master Cylinders	99.85%	99.86%	99.87%	99.88%	99.89%	99.89%	99.90%	99.91%	99.91%	99.92%	99.92%	99.93%	99.93%	99.94%	99.94%
105	Front Disc Brakes	99.55%	99.58%	99.61%	99.64%	99.66%	99.68%	99.70%	99.72%	99.74%	99.76%	99.77%	99.78%	99.80%	99.81%	99.82%
201	Instrument Panel Padding	99.63%	99.65%	99.68%	99.70%	99.72%	99.74%	99.76%	99.77%	99.79%	99.80%	99.81%	99.82%	99.83%	99.84%	99.85%
203/204	Energy Absorbing Steering Columns	99.28%	99.33%	99.38%	99.42%	99.46%	99.50%	99.53%	99.56%	99.59%	99.61%	99.64%	99.66%	99.68%	99.70%	99.71%
206	Improved Door Locks	99.85%	99.86%	99.87%	99.88%	99.89%	99.89%	99.90%	99.91%	99.91%	99.92%	99.92%	99.93%	99.93%	99.94%	99.94%
208	Driver Frontal Air Bags	75.18%	77.68%	79.87%	81.79%	83.47%	84.95%	86.24%	87.38%	88.39%	89.27%	90.05%	90.74%	91.35%	91.90%	92.38%
208	Passenger Frontal Air Bags	66.53%	69.87%	72.84%	75.46%	77.77%	79.82%	81.62%	83.21%	84.62%	85.86%	86.97%	87.94%	88.81%	89.59%	90.27%
212	Windshield Adhesive Bonding	98.80%	98.88%	98.96%	99.03%	99.10%	99.16%	99.22%	99.27%	99.31%	99.36%	99.39%	99.43%	99.46%	99.49%	99.52%
214	Side Door Beams	94.04%	94.47%	94.86%	95.22%	95.55%	95.85%	96.12%	96.37%	96.60%	96.81%	97.00%	97.18%	97.34%	97.50%	97.64%
214	TTI Reduction (Already PC&LTV)	72.25%	75.05%	77.51%	79.67%	81.57%	83.24%	84.71%	86.00%	87.14%	88.14%	89.03%	89.82%	90.51%	91.13%	91.69%
214	Side Air Bags - Torso (PC&LTV)	30.04%	36.07%	41.64%	46.75%	51.42%	55.67%	59.53%	63.01%	66.16%	69.00%	71.55%	73.85%	75.91%	77.77%	79.44%
214	Side Air Bags - Head (PC&LTV)	27.51%	33.68%	39.38%	44.64%	49.45%	53.84%	57.83%	61.44%	64.71%	67.66%	70.32%	72.71%	74.87%	76.81%	78.55%
216	Roof Crush Strength (PC Only)	99.47%	99.51%	99.54%	99.57%	99.60%	99.63%	99.65%	99.68%	99.70%	99.72%	99.73%	99.75%	99.76%	99.78%	99.79%
126	Electronic Stability Control	5.43%	7.77%	10.82%	14.34%	18.08%	22.62%	28.06%	33.48%	38.51%	43.18%	47.49%	51.46%	55.10%	58.44%	61.50%
105/121	Medium/Heavy Truck ABS	66.86%	70.18%	73.12%	75.71%	78.00%	80.02%	81.80%	83.38%	84.77%	86.00%	87.09%	88.06%	88.92%	89.68%	90.36%
201	Upper Interior Head Impact Protection	34.37%	40.16%	45.48%	50.34%	54.76%	58.77%	62.39%	65.66%	68.60%	71.24%	73.62%	75.75%	77.66%	79.38%	80.92%
138	TPMS	0.74%	3.97%	9.82%	16.44%	22.70%	28.59%	34.09%	39.20%	43.93%	48.29%	52.30%	55.97%	59.33%	62.39%	65.19%
214	Oblique Pole Test	7.88%	10.11%	12.23%	14.24%	16.13%	17.92%	19.60%	21.66%	25.66%	30.96%	35.91%	40.51%	44.78%	48.73%	52.38%
NA	Ejection Mitigation	0.94%	1.78%	2.91%	4.23%	5.49%	6.70%	7.85%	9.86%	14.27%	20.00%	25.41%	30.49%	35.25%	39.69%	43.82%
121	Heavy Truck Stopping Distance				0.00%	3.41%	9.99%	16.22%	22.12%	27.67%	32.87%	37.73%	42.24%	46.41%	50.27%	53.83%
208	Seat Belt Usage Rate	81.00%	82.52%	83.92%	85.20%	86.39%	87.48%	88.48%	89.40%	90.25%	91.03%	91.75%	92.41%	93.01%	93.57%	94.09%

Table A-3
Cumulative On-Road Fleet and Cumulative Retirements by Vehicle Age
Passenger Cars

							Cumulative	
Vehicle Age	**Survival Rate**	**Retirement Rate**	**On-Road Fleet Profile**	**Annual Retirements**	**Retirements by Age**	**On-Road Fleet by Age**	**On-Road Fleet by Age**	**Cumulative Retirements by Age**
1	0.9900	0.0100	8,000,000	79,839	1.49%	6.13%	6.13%	1.49%
2	0.9831	0.0069	8,053,834	55,744	1.04%	6.17%	12.31%	2.54%
3	0.9731	0.0100	8,005,049	80,437	1.50%	6.14%	18.44%	4.04%
4	0.9593	0.0138	8,758,284	120,775	2.26%	6.71%	25.16%	6.30%
5	0.9413	0.0180	7,966,759	143,430	2.68%	6.11%	31.27%	8.98%
6	0.9188	0.0225	7,400,233	166,418	3.11%	5.67%	36.94%	12.09%
7	0.8918	0.0270	7,631,081	206,117	3.85%	5.85%	42.79%	15.94%
8	0.8604	0.0313	7,076,943	221,747	4.15%	5.43%	48.22%	20.09%
9	0.8252	0.0352	8,160,683	287,642	5.38%	6.26%	54.47%	25.47%
10	0.7866	0.0386	7,069,872	272,773	5.10%	5.42%	59.89%	30.57%
11	0.7170	0.0696	6,904,614	480,784	8.99%	5.29%	65.19%	39.56%
12	0.6125	0.1045	6,238,595	651,774	12.19%	4.78%	69.97%	51.74%
13	0.5094	0.1031	6,049,746	623,911	11.67%	4.64%	74.61%	63.41%
14	0.4142	0.0951	5,785,594	550,444	10.29%	4.44%	79.04%	73.70%
15	0.3308	0.0834	5,562,610	463,960	8.67%	4.26%	83.31%	82.38%
16	0.2604	0.0704	4,876,582	343,153	6.42%	3.74%	87.05%	88.79%
17	0.2028	0.0577	4,045,657	233,342	4.36%	3.10%	90.15%	93.16%
18	0.1565	0.0463	3,361,057	155,483	2.91%	2.58%	92.72%	96.06%
19	0.1200	0.0365	2,518,942	91,948	1.72%	1.93%	94.65%	97.78%
20	0.0916	0.0285	1,885,341	53,641	1.00%	1.45%	96.10%	98.78%
21	0.0696	0.0220	1,109,748	24,385	0.46%	0.85%	96.95%	99.24%
22	0.0527	0.0169	717,732	12,096	0.23%	0.55%	97.50%	99.47%
23	0.0399	0.0129	591,767	7,609	0.14%	0.45%	97.95%	99.61%
24	0.0301	0.0098	494,398	4,831	0.09%	0.38%	98.33%	99.70%
25+	0.0227	0.0074	2,173,404	16,095	0.30%	1.67%	100.00%	100.00%
Total		0.9773	130,438,525	5,348,376	1.0000	1.0000		

Table A-4
Cumulative On-Road Fleet and Cumulative Retirements by Vehicle Age
Light Trucks

							Cumulative	
Vehicle Age	Survival Rate	Retirement Rate	On-Road Fleet Profile	Annual Retirements	Retirements by age	On-Road Fleet by Age	On-Road Fleet by Age	Cumulative Retirements by Age
1	0.9741	0.0259	7,800,000	201,953	7.19%	9.01%	9.01%	7.19%
2	0.9603	0.0138	7,800,519	107,998	3.85%	9.01%	18.01%	11.04%
3	0.9420	0.0183	7,035,283	128,474	4.58%	8.12%	26.14%	15.61%
4	0.9190	0.0230	7,028,541	161,537	5.75%	8.12%	34.25%	21.37%
5	0.8913	0.0278	6,456,982	179,189	6.38%	7.46%	41.71%	27.75%
6	0.8590	0.0323	5,678,888	183,450	6.53%	6.56%	48.26%	34.28%
7	0.8226	0.0364	5,318,882	193,642	6.90%	6.14%	54.41%	41.18%
8	0.7827	0.0399	4,407,753	175,758	6.26%	5.09%	59.50%	47.44%
9	0.7401	0.0426	4,679,603	199,280	7.10%	5.40%	64.90%	54.54%
10	0.6956	0.0445	4,336,664	192,880	6.87%	5.01%	69.91%	61.41%
11	0.6501	0.0455	3,520,685	160,357	5.71%	4.07%	73.97%	67.12%
12	0.6042	0.0458	2,827,293	129,602	4.62%	3.26%	77.24%	71.73%
13	0.5517	0.0525	2,589,751	136,083	4.85%	2.99%	80.23%	76.58%
14	0.5009	0.0508	2,340,504	118,972	4.24%	2.70%	82.93%	80.82%
15	0.4522	0.0487	2,539,888	123,595	4.40%	2.93%	85.86%	85.22%
16	0.4062	0.0460	2,298,883	105,667	3.76%	2.65%	88.52%	88.98%
17	0.3633	0.0429	1,802,394	77,352	2.75%	2.08%	90.60%	91.74%
18	0.3236	0.0397	1,678,087	66,569	2.37%	1.94%	92.53%	94.11%
19	0.2873	0.0364	1,301,325	47,304	1.68%	1.50%	94.04%	95.79%
20	0.2542	0.0331	1,066,249	35,250	1.26%	1.23%	95.27%	97.05%
21	0.2244	0.0299	641,888	19,173	0.68%	0.74%	96.01%	97.73%
22	0.1975	0.0268	492,438	13,215	0.47%	0.57%	96.58%	98.20%
23	0.1735	0.0240	399,337	9,581	0.34%	0.46%	97.04%	98.54%
24	0.1522	0.0214	333,308	7,119	0.25%	0.38%	97.42%	98.79%
25	0.1332	0.0189	621,374	11,772	0.42%	0.72%	98.14%	99.21%
26	0.1165	0.0168	536,874	8,993	0.32%	0.62%	98.76%	99.53%
27	0.1017	0.0148	415,832	6,142	0.22%	0.48%	99.24%	99.75%
28	0.0887	0.0130	289,805	3,765	0.13%	0.33%	99.58%	99.89%
29	0.0773	0.0114	81,654	931	0.03%	0.09%	99.67%	99.92%
30	0.0673	0.0100	71,447	714	0.03%	0.08%	99.75%	99.95%
31	0.0586	0.0087	61,241	535	0.02%	0.07%	99.82%	99.96%
32	0.0509	0.0076	51,034	390	0.01%	0.06%	99.88%	99.98%
33	0.0443	0.0067	40,827	272	0.01%	0.05%	99.93%	99.99%
34	0.0385	0.0058	30,620	178	0.01%	0.04%	99.96%	99.99%
35	0.0334	0.0051	20,414	103	0.00%	0.02%	99.99%	100.00%
36	0.0290	0.0044	10,207	45	0.00%	0.01%	100.00%	100.00%
		0.9710	86,606,473	2,807,843	100.00%	100.00%		

Table A-5
Cumulative On-Road Fleet and Cumulative Retirements by Vehicle Age
Passenger Cars and LTVs

					Cumulative	
Vehicle Age	**Annual Retirements**	**Retirements by Age**	**On-Road Fleet Profile**	**On-Road Fleet by Age**	**On-Road Fleet by Age**	**Cumulative Retirements by Age**
1	281,791	3.45%	15,800,000	7.28%	7.28%	3.45%
2	163,742	2.01%	15,854,353	7.30%	14.58%	5.46%
3	208,912	2.56%	15,040,332	6.93%	21.51%	8.02%
4	282,312	3.46%	15,786,825	7.27%	28.79%	11.49%
5	322,619	3.96%	14,423,741	6.65%	35.43%	15.44%
6	349,868	4.29%	13,079,121	6.03%	41.46%	19.73%
7	399,759	4.90%	12,949,963	5.97%	47.43%	24.63%
8	397,505	4.87%	11,484,696	5.29%	52.72%	29.51%
9	486,921	5.97%	12,840,286	5.92%	58.63%	35.48%
10	465,653	5.71%	11,406,536	5.26%	63.89%	41.18%
11	641,141	7.86%	10,425,299	4.80%	68.69%	49.05%
12	781,376	9.58%	9,065,888	4.18%	72.87%	58.63%
13	759,994	9.32%	8,639,497	3.98%	76.85%	67.94%
14	669,416	8.21%	8,126,098	3.74%	80.59%	76.15%
15	587,555	7.20%	8,102,498	3.73%	84.33%	83.35%
16	448,820	5.50%	7,175,465	3.31%	87.63%	88.86%
17	310,694	3.81%	5,848,051	2.69%	90.33%	92.67%
18	222,052	2.72%	5,039,144	2.32%	92.65%	95.39%
19	139,252	1.71%	3,820,267	1.76%	94.41%	97.10%
20	88,891	1.09%	2,951,590	1.36%	95.77%	98.19%
21	43,558	0.53%	1,751,636	0.81%	96.58%	98.72%
22	25,311	0.31%	1,210,170	0.56%	97.13%	99.03%
23	17,190	0.21%	991,104	0.46%	97.59%	99.24%
24	11,951	0.15%	827,706	0.38%	97.97%	99.39%
25	27,867	0.34%	2,794,778	1.29%	99.26%	99.73%
26	8,993	0.11%	536,874	0.25%	99.51%	99.84%
27	6,142	0.08%	415,832	0.19%	99.70%	99.91%
28	3,765	0.05%	289,805	0.13%	99.83%	99.96%
29	931	0.01%	81,654	0.04%	99.87%	99.97%
30	714	0.01%	71,447	0.03%	99.90%	99.98%
31	535	0.01%	61,241	0.03%	99.93%	99.99%
32	390	0.00%	51,034	0.02%	99.95%	99.99%
33	272	0.00%	40,827	0.02%	99.97%	100.00%
34	178	0.00%	30,620	0.01%	99.99%	100.00%
35	103	0.00%	20,414	0.01%	100.00%	100.00%
36	45	0.00%	10,207	0.00%	100.00%	100.00%
	8,156,219	100.00%	217,044,998	100.00%		

Appendix B – Results Tables

Table B-1 All Fatalities
Fatality Rate Impacts of Behavioral Programs and Proposed Safety Standards
<<<<<<<<<<<<<<<<<**Removed Impacts**>>>>>>>>>>>>>>>>>>>>>>>>>

	Base Estimate	**Seat Belts**	**Alcohol Improv.**	**Combined Behavioral**	**ESC**	**Heavy-Truck Brakes**	**Side Impact**	**Ejection Mitigation**	**Proposed Standards**	**All NHTSA Activities**
2005	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45
2006	1.44	1.44	1.45	1.45	1.44	1.44	1.44	1.44	1.44	1.45
2007	1.41	1.42	1.42	1.44	1.41	1.41	1.41	1.41	1.41	1.44
2008	1.37	1.40	1.39	1.42	1.37	1.37	1.37	1.37	1.37	1.42
2009	1.34	1.37	1.36	1.40	1.34	1.34	1.34	1.34	1.34	1.40
2010	1.30	1.35	1.33	1.38	1.31	1.30	1.30	1.30	1.31	1.39
2011	1.27	1.32	1.30	1.36	1.28	1.27	1.27	1.27	1.28	1.37
2012	1.23	1.29	1.27	1.33	1.25	1.23	1.23	1.23	1.26	1.36
2013	1.20	1.26	1.24	1.31	1.23	1.20	1.20	1.20	1.23	1.35
2014	1.16	1.24	1.21	1.28	1.21	1.17	1.17	1.16	1.21	1.33
2015	1.13	1.21	1.18	1.26	1.18	1.13	1.14	1.14	1.19	1.32
2016	1.10	1.19	1.15	1.24	1.16	1.11	1.11	1.11	1.17	1.31
2017	1.08	1.17	1.13	1.22	1.14	1.08	1.08	1.08	1.15	1.30
2018	1.06	1.14	1.11	1.20	1.12	1.06	1.06	1.06	1.14	1.30
2019	1.03	1.13	1.09	1.18	1.11	1.04	1.04	1.04	1.12	1.29
2020	1.01	1.11	1.07	1.17	1.09	1.02	1.02	1.02	1.11	1.28

Table B-2 All Fatalities
Fatality Rate Impacts of Behavioral Programs and Proposed Safety Standards
Change From Base Estimate
<<<<<<<<<<<<<<<<<<**Removed Impacts**>>>>>>>>>>>>>>>>>>>>>>>>>

	Base Estimate	**Seat Belts**	**Alcohol Improv.**	**Combined Behavioral**	**ESC**	**Heavy-Truck Brakes**	**Side Impact**	**Ejection Mitigation**	**Proposed Standards**	**All NHTSA Activities**
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	-0.01
2007	0.00	-0.01	-0.02	-0.03	0.00	0.00	0.00	0.00	0.00	-0.03
2008	0.00	-0.03	-0.02	-0.05	0.00	0.00	0.00	0.00	0.00	-0.05
2009	0.00	-0.04	-0.03	-0.06	0.00	0.00	0.00	0.00	0.00	-0.07
2010	0.00	-0.05	-0.03	-0.08	-0.01	0.00	0.00	0.00	-0.01	-0.09
2011	0.00	-0.05	-0.03	-0.09	-0.01	0.00	0.00	0.00	-0.02	-0.11
2012	0.00	-0.06	-0.04	-0.10	-0.02	0.00	0.00	0.00	-0.02	-0.13
2013	0.00	-0.07	-0.04	-0.11	-0.03	0.00	0.00	0.00	-0.04	-0.15
2014	0.00	-0.07	-0.04	-0.12	-0.04	0.00	0.00	0.00	-0.05	-0.17
2015	0.00	-0.08	-0.05	-0.13	-0.05	0.00	0.00	0.00	-0.06	-0.19
2016	0.00	-0.08	-0.05	-0.13	-0.06	0.00	0.00	0.00	-0.07	-0.21
2017	0.00	-0.09	-0.05	-0.14	-0.06	0.00	-0.01	0.00	-0.08	-0.23
2018	0.00	-0.09	-0.05	-0.15	-0.07	0.00	-0.01	-0.01	-0.08	-0.24
2019	0.00	-0.09	-0.05	-0.15	-0.07	0.00	-0.01	-0.01	-0.09	-0.25
2020	0.00	-0.10	-0.05	-0.16	-0.08	0.00	-0.01	-0.01	-0.10	-0.27

Table C-1 All Fatalities Excluding Motorcycles
Fatality Rate Impacts of Behavioral Programs and Proposed Safety Standards
<<<<<<<<<<<<<<<<<<**Removed Impacts**>>>>>>>>>>>>>>>>>>>>>>>>>

	Base Estimate	**Seat Belts**	**Alcohol Improv.**	**Combined Behavioral**	**ESC**	**Heavy-Truck Brakes**	**Side Impact**	**Ejection Mitigation**	**Proposed Standards**	**All NHTSA Activities**
2005	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31
2006	1.29	1.29	1.30	1.30	1.29	1.29	1.29	1.29	1.29	1.30
2007	1.25	1.27	1.27	1.28	1.25	1.25	1.25	1.25	1.25	1.28
2008	1.21	1.24	1.24	1.26	1.22	1.21	1.21	1.21	1.22	1.26
2009	1.18	1.22	1.21	1.24	1.18	1.18	1.18	1.18	1.18	1.25
2010	1.15	1.19	1.18	1.23	1.16	1.15	1.15	1.15	1.16	1.24
2011	1.12	1.17	1.15	1.21	1.13	1.12	1.12	1.12	1.13	1.22
2012	1.09	1.15	1.13	1.19	1.11	1.09	1.09	1.09	1.11	1.22
2013	1.06	1.13	1.11	1.18	1.09	1.06	1.06	1.06	1.10	1.21
2014	1.04	1.11	1.09	1.16	1.08	1.04	1.04	1.04	1.08	1.21
2015	1.02	1.09	1.07	1.15	1.06	1.02	1.02	1.02	1.07	1.21
2016	1.00	1.08	1.05	1.14	1.05	1.00	1.00	1.00	1.06	1.21
2017	0.98	1.07	1.04	1.13	1.04	0.98	0.99	0.98	1.05	1.21
2018	0.96	1.05	1.03	1.12	1.03	0.97	0.97	0.97	1.05	1.22
2019	0.95	1.04	1.01	1.11	1.02	0.95	0.96	0.96	1.04	1.22
2020	0.94	1.03	1.00	1.10	1.01	0.94	0.95	0.94	1.03	1.22

Table C-2 All Fatalities Excluding Motorcycles
Fatality Rate Impacts of Behavioral Programs and Proposed Safety Standards
Change From Base Estimate
<<<<<<<<<<<<<<<<<<**Removed Impacts**>>>>>>>>>>>>>>>>>>>>>>>>

	Base Estimate	**Seat Belts**	**Alcohol Improv.**	**Combined Behavioral**	**ESC**	**Heavy-Truck Brakes**	**Side Impact**	**Ejection Mitigation**	**Proposed Standards**	**All NHTSA Activities**
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	-0.01
2007	0.00	-0.01	-0.02	-0.03	0.00	0.00	0.00	0.00	0.00	-0.03
2008	0.00	-0.03	-0.02	-0.05	0.00	0.00	0.00	0.00	0.00	-0.05
2009	0.00	-0.04	-0.03	-0.06	0.00	0.00	0.00	0.00	0.00	-0.07
2010	0.00	-0.05	-0.03	-0.08	-0.01	0.00	0.00	0.00	-0.01	-0.09
2011	0.00	-0.05	-0.04	-0.09	-0.01	0.00	0.00	0.00	-0.02	-0.11
2012	0.00	-0.06	-0.04	-0.10	-0.02	0.00	0.00	0.00	-0.02	-0.13
2013	0.00	-0.07	-0.04	-0.12	-0.03	0.00	0.00	0.00	-0.04	-0.15
2014	0.00	-0.07	-0.05	-0.13	-0.04	0.00	0.00	0.00	-0.05	-0.18
2015	0.00	-0.08	-0.05	-0.13	-0.05	0.00	0.00	0.00	-0.06	-0.20
2016	0.00	-0.08	-0.06	-0.14	-0.06	0.00	0.00	0.00	-0.07	-0.22
2017	0.00	-0.09	-0.06	-0.15	-0.06	0.00	-0.01	0.00	-0.07	-0.23
2018	0.00	-0.09	-0.06	-0.16	-0.07	0.00	-0.01	-0.01	-0.08	-0.25
2019	0.00	-0.09	-0.06	-0.16	-0.07	0.00	-0.01	-0.01	-0.09	-0.27
2020	0.00	-0.09	-0.07	-0.17	-0.08	0.00	-0.01	-0.01	-0.09	-0.28

Table D-1 Passenger Vehicles Only
Fatality Rate Impacts of Behavioral Programs and Proposed Safety Standards

<<<<<<<<<<<<<<<<<<**Removed Impacts**>>>>>>>>>>>>>>>>>>>>>>>>>

	Base Estimate	**Seat Belts**	**Alcohol Improv.**	**Combined Behavioral**	**ESC**	**Heavy-Truck Brakes**	**Side Impact**	**Ejection Mitigation**	**Proposed Standards**	**All NHTSA Activities**
2005	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14
2006	1.13	1.13	1.14	1.14	1.13	1.13	1.13	1.13	1.13	1.14
2007	1.09	1.10	1.10	1.12	1.09	1.09	1.09	1.09	1.09	1.12
2008	1.05	1.08	1.07	1.10	1.05	1.05	1.05	1.05	1.05	1.10
2009	1.01	1.05	1.03	1.07	1.02	1.01	1.01	1.01	1.02	1.08
2010	0.98	1.03	1.00	1.05	0.98	0.98	0.98	0.98	0.98	1.06
2011	0.94	1.00	0.97	1.03	0.95	0.94	0.94	0.94	0.95	1.05
2012	0.90	0.97	0.93	1.00	0.93	0.90	0.90	0.90	0.93	1.03
2013	0.86	0.94	0.90	0.98	0.90	0.87	0.86	0.86	0.90	1.02
2014	0.83	0.91	0.87	0.95	0.87	0.83	0.83	0.83	0.88	1.01
2015	0.80	0.88	0.84	0.93	0.85	0.80	0.80	0.80	0.86	0.99
2016	0.77	0.86	0.81	0.90	0.83	0.77	0.77	0.77	0.84	0.98
2017	0.74	0.83	0.78	0.88	0.81	0.74	0.75	0.74	0.82	0.97
2018	0.71	0.81	0.76	0.86	0.79	0.72	0.72	0.72	0.80	0.96
2019	0.69	0.79	0.74	0.84	0.77	0.69	0.70	0.70	0.79	0.96
2020	0.67	0.77	0.72	0.83	0.75	0.67	0.68	0.68	0.77	0.95

Table D-2 Passenger Vehicles Only
Fatality Rate Impacts of Behavioral Programs and Proposed Safety Standards
Change From Base Estimate

<<<<<<<<<<<<<<<<<<**Removed Impacts**>>>>>>>>>>>>>>>>>>>>>>>>>

	Base Estimate	**Seat Belts**	**Alcohol Improv.**	**Combined Behavioral**	**ESC**	**Heavy-Truck Brakes**	**Side Impact**	**Ejection Mitigation**	**Proposed Standards**	**All NHTSA Activities**
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	-0.01
2007	0.00	-0.01	-0.01	-0.03	0.00	0.00	0.00	0.00	0.00	-0.03
2008	0.00	-0.03	-0.02	-0.05	0.00	0.00	0.00	0.00	0.00	-0.05
2009	0.00	-0.04	-0.02	-0.06	0.00	0.00	0.00	0.00	0.00	-0.07
2010	0.00	-0.05	-0.03	-0.08	-0.01	0.00	0.00	0.00	-0.01	-0.09
2011	0.00	-0.06	-0.03	-0.09	-0.02	0.00	0.00	0.00	-0.02	-0.11
2012	0.00	-0.07	-0.03	-0.10	-0.03	0.00	0.00	0.00	-0.03	-0.13
2013	0.00	-0.07	-0.04	-0.11	-0.04	0.00	0.00	0.00	-0.04	-0.15
2014	0.00	-0.08	-0.04	-0.12	-0.05	0.00	0.00	0.00	-0.05	-0.18
2015	0.00	-0.09	-0.04	-0.13	-0.05	0.00	0.00	0.00	-0.06	-0.20
2016	0.00	-0.09	-0.04	-0.14	-0.06	0.00	-0.01	0.00	-0.07	-0.22
2017	0.00	-0.09	-0.04	-0.14	-0.07	0.00	-0.01	0.00	-0.08	-0.23
2018	0.00	-0.10	-0.05	-0.15	-0.07	0.00	-0.01	-0.01	-0.09	-0.25
2019	0.00	-0.10	-0.05	-0.15	-0.08	0.00	-0.01	-0.01	-0.10	-0.26
2020	0.00	-0.10	-0.05	-0.16	-0.08	0.00	-0.01	-0.01	-0.10	-0.28

Table E-1 Passenger Vehicles and Motorcycles
Fatality Rate Impacts of Behavioral Programs and Proposed Safety Standards
<<<<<<<<<<<<<<<<<<<<<<<<<<<<<**Removed Impacts**>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>

	Base Estimate	Seat Belts	Alcohol Improv.	Combined Behavioral	ESC	Heavy-Truck Brakes	Side Impact	Ejection Mitigation	Proposed Standards	All NHTSA Activities
2005	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
2006	1.29	1.29	1.30	1.30	1.29	1.29	1.29	1.29	1.29	1.30
2007	1.26	1.27	1.27	1.29	1.26	1.26	1.26	1.26	1.26	1.29
2008	1.22	1.25	1.24	1.27	1.22	1.22	1.22	1.22	1.22	1.27
2009	1.18	1.22	1.20	1.24	1.18	1.18	1.18	1.18	1.18	1.25
2010	1.14	1.19	1.17	1.22	1.15	1.14	1.14	1.14	1.15	1.23
2011	1.10	1.15	1.13	1.19	1.11	1.10	1.10	1.10	1.11	1.21
2012	1.05	1.12	1.09	1.15	1.07	1.05	1.05	1.05	1.08	1.18
2013	1.00	1.08	1.04	1.12	1.04	1.00	1.00	1.00	1.04	1.16
2014	0.96	1.04	1.00	1.08	1.00	0.96	0.96	0.96	1.01	1.14
2015	0.91	1.00	0.96	1.05	0.96	0.91	0.92	0.91	0.97	1.11
2016	0.87	0.96	0.92	1.01	0.93	0.87	0.87	0.87	0.94	1.09
2017	0.83	0.92	0.88	0.98	0.90	0.83	0.84	0.83	0.91	1.07
2018	0.79	0.89	0.85	0.95	0.87	0.80	0.80	0.80	0.88	1.05
2019	0.76	0.86	0.82	0.92	0.84	0.76	0.77	0.77	0.86	1.03
2020	0.73	0.83	0.79	0.90	0.81	0.73	0.74	0.74	0.83	1.02

Table E-2 Passenger Vehicles and Motorcycles
Fatality Rate Impacts of Behavioral Programs and Proposed Safety Standards
Change From Base Estimate
<<<<<<<<<<<<<<<<<<<<<<<<<<<<<**Removed Impacts**>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>

	Base Estimate	Seat Belts	Alcohol Improv.	Combined Behavioral	ESC	Heavy-Truck Brakes	Side Impact	Ejection Mitigation	Proposed Standards	All NHTSA Activities
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	-0.01
2007	0.00	-0.01	-0.01	-0.03	0.00	0.00	0.00	0.00	0.00	-0.03
2008	0.00	-0.03	-0.02	-0.05	0.00	0.00	0.00	0.00	0.00	-0.05
2009	0.00	-0.04	-0.02	-0.06	0.00	0.00	0.00	0.00	0.00	-0.07
2010	0.00	-0.05	-0.03	-0.08	-0.01	0.00	0.00	0.00	-0.01	-0.09
2011	0.00	-0.06	-0.03	-0.09	-0.02	0.00	0.00	0.00	-0.02	-0.11
2012	0.00	-0.07	-0.04	-0.10	-0.03	0.00	0.00	0.00	-0.03	-0.13
2013	0.00	-0.07	-0.04	-0.12	-0.04	0.00	0.00	0.00	-0.04	-0.16
2014	0.00	-0.08	-0.04	-0.13	-0.04	0.00	0.00	0.00	-0.05	-0.18
2015	0.00	-0.08	-0.05	-0.13	-0.05	0.00	0.00	0.00	-0.06	-0.20
2016	0.00	-0.09	-0.05	-0.14	-0.06	0.00	-0.01	0.00	-0.07	-0.22
2017	0.00	-0.09	-0.05	-0.15	-0.07	0.00	-0.01	0.00	-0.08	-0.24
2018	0.00	-0.10	-0.06	-0.16	-0.07	0.00	-0.01	-0.01	-0.09	-0.26
2019	0.00	-0.10	-0.06	-0.16	-0.08	0.00	-0.01	-0.01	-0.10	-0.27
2020	0.00	-0.10	-0.06	-0.17	-0.08	0.00	-0.01	-0.01	-0.10	-0.29

Table F-1 Nonoccupants
Fatality Rate Impacts of Behavioral Programs and Proposed Safety Standards

<<<<<<<<<<<<<<<<<<**Removed Impacts**>>>>>>>>>>>>>>>>>>>>>>>>>

	Base Estimate	Seat Belts	Alcohol Improv.	Combined Behavioral	ESC	Heavy-Truck Brakes	Side Impact	Ejection Mitigation	Proposed Standards	All NHTSA Activities
2005	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
2006	0.19	0.19	0.20	0.20	0.19	0.19	0.19	0.19	0.19	0.20
2007	0.19	0.19	0.20	0.20	0.19	0.19	0.19	0.19	0.19	0.20
2008	0.19	0.19	0.20	0.20	0.19	0.19	0.19	0.19	0.19	0.20
2009	0.19	0.19	0.20	0.20	0.19	0.19	0.19	0.19	0.19	0.20
2010	0.19	0.19	0.20	0.20	0.19	0.19	0.19	0.19	0.19	0.20
2011	0.19	0.19	0.20	0.20	0.19	0.19	0.19	0.19	0.19	0.20
2012	0.19	0.19	0.20	0.20	0.19	0.19	0.19	0.19	0.19	0.20
2013	0.19	0.19	0.20	0.20	0.19	0.19	0.19	0.19	0.19	0.20
2014	0.19	0.19	0.20	0.20	0.19	0.19	0.19	0.19	0.19	0.20
2015	0.19	0.19	0.20	0.20	0.19	0.19	0.19	0.19	0.19	0.20
2016	0.19	0.19	0.20	0.20	0.19	0.19	0.19	0.19	0.19	0.20
2017	0.19	0.19	0.20	0.20	0.19	0.19	0.19	0.19	0.19	0.20
2018	0.19	0.19	0.20	0.20	0.19	0.19	0.19	0.19	0.19	0.20
2019	0.18	0.18	0.20	0.20	0.18	0.18	0.18	0.18	0.18	0.20
2020	0.18	0.18	0.20	0.20	0.18	0.18	0.18	0.18	0.18	0.20

Table F-2 Nonoccupants
Fatality Rate Impacts of Behavioral Programs and Proposed Safety Standards
Change From Base Estimate

<<<<<<<<<<<<<<<<<<**Removed Impacts** >>>>>>>>>>>>>>>>>>>>>>>>>>>>>

	Base Estimate	Seat Belts	Alcohol Improv.	Combined Behavioral	ESC	Heavy-Truck Brakes	Side Impact	Ejection Mitigation	Proposed Standards	All NHTSA Activities
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2008	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2009	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2011	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	-0.01
2012	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	-0.01
2013	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	-0.01
2014	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	-0.01
2015	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	-0.01
2016	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	-0.01
2017	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	-0.01
2018	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	-0.01
2019	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	-0.01
2020	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	-0.01

Table G-1 All Fatalities
Fatality Impacts of Behavioral Programs and Proposed Safety Standards
<<<<<<<<<<<<<<<<<<**Removed Impacts**>>>>>>>>>>>>>>>>>>>>>>>>>

	Base Estimate	Seat Belts	Alcohol Improv.	Combined Behavioral	ESC	Heavy-Truck Brakes	Side Impact	Ejection Mitigation	Proposed Standards	All NHTSA Activities
2005	43,443	43,443	43,443	43,443	43,443	43,443	43,443	43,443	43,443	43,443
2006	43,751	43,751	44,045	44,045	43,751	43,751	43,751	43,751	43,751	44,045
2007	43,363	43,778	43,839	44,258	43,363	43,363	43,363	43,363	43,363	44,258
2008	42,897	43,696	43,544	44,355	42,932	42,897	42,897	42,897	42,932	44,392
2009	42,410	43,565	43,218	44,394	42,539	42,410	42,410	42,410	42,539	44,530
2010	41,945	43,428	42,906	44,423	42,203	41,951	41,945	41,945	42,209	44,703
2011	41,383	43,163	42,484	44,311	41,860	41,400	41,383	41,383	41,877	44,841
2012	40,827	42,877	42,058	44,171	41,625	40,853	40,827	40,827	41,652	45,065
2013	40,297	42,594	41,651	44,025	41,426	40,333	40,304	40,305	41,479	45,320
2014	39,784	42,306	41,253	43,867	41,219	39,829	39,833	39,823	41,356	45,604
2015	39,306	42,032	40,882	43,717	41,023	39,358	39,417	39,386	41,278	45,915
2016	38,900	41,815	40,578	43,619	40,878	38,959	39,067	39,019	41,242	46,252
2017	38,561	41,653	40,338	43,572	40,779	38,627	38,781	38,715	41,247	46,615
2018	38,285	41,542	40,157	43,573	40,725	38,357	38,553	38,473	41,289	47,002
2019	38,068	41,481	40,031	43,620	40,713	38,145	38,380	38,286	41,367	47,412
2020	37,906	41,467	39,957	43,711	40,741	37,988	38,258	38,152	41,480	47,845

Table G-2 All Fatalities
Fatality Impacts of Behavioral Programs and Proposed Safety Standards
Change From Base Estimate
<<<<<<<<<<<<<<<<<<**Removed Impacts**>>>>>>>>>>>>>>>>>>>>>>>>>

	Base Estimate	Seat Belts	Alcohol Improv.	Combined Behavioral	ESC	Heavy-Truck Brakes	Side Impact	Ejection Mitigation	Proposed Standards	All NHTSA Activities
2005	0	0	0	0	0	0	0	0	0	0
2006	0	0	-294	-294	0	0	0	0	0	-294
2007	0	-415	-475	-895	0	0	0	0	0	-895
2008	0	-800	-647	-1458	-35	0	0	0	-35	-1495
2009	0	-1155	-808	-1985	-129	0	0	0	-129	-2120
2010	0	-1483	-961	-2478	-258	-6	0	0	-264	-2758
2011	0	-1780	-1101	-2928	-477	-17	0	0	-494	-3458
2012	0	-2051	-1232	-3344	-798	-27	0	0	-825	-4239
2013	0	-2297	-1354	-3729	-1129	-36	-8	-8	-1183	-5023
2014	0	-2521	-1468	-4083	-1435	-44	-48	-38	-1572	-5819
2015	0	-2726	-1576	-4411	-1717	-52	-110	-80	-1971	-6609
2016	0	-2915	-1678	-4719	-1978	-59	-167	-119	-2342	-7352
2017	0	-3092	-1777	-5011	-2218	-66	-220	-154	-2686	-8054
2018	0	-3257	-1872	-5288	-2440	-72	-268	-187	-3004	-8717
2019	0	-3413	-1963	-5553	-2645	-78	-312	-218	-3300	-9345
2020	0	-3561	-2052	-5805	-2835	-83	-353	-247	-3574	-9939

Table H-1 All Fatalities Excluding Motorcycles
Fatality Impacts of Behavioral Programs and Proposed Safety Standards
<<<<<<<<<<<<<<<<<<**Removed Impacts**>>>>>>>>>>>>>>>>>>>>>>>>

	Base Estimate	Seat Belts	Alcohol Improv.	Combined Behavioral	ESC	Heavy-Truck Brakes	Side Impact	Ejection Mitigation	Proposed Standards	All NHTSA Activities
2005	38890	38890	38890	38890	38890	38890	38890	38890	38890	38890
2006	38979	38979	39270	39270	38979	38979	38979	38979	38979	39270
2007	38419	38834	38898	39317	38419	38419	38419	38419	38419	39317
2008	37838	38637	38499	39311	37873	37838	37838	37838	37873	39347
2009	37299	38453	38138	39315	37428	37299	37299	37299	37428	39450
2010	36849	38328	37861	39378	37106	36854	36849	36849	37112	39658
2011	36365	38140	37543	39370	36840	36381	36365	36365	36857	39900
2012	35946	37989	37284	39396	36741	35973	35946	35946	36768	40291
2013	35605	37891	37098	39472	36728	35640	35612	35613	36782	40767
2014	35321	37827	36965	39579	36748	35365	35369	35359	36883	41316
2015	35099	37805	36890	39725	36804	35151	35208	35178	37056	41923
2016	34961	37851	36897	39938	36922	35019	35127	35078	37283	42571
2017	34886	37947	36968	40202	37082	34951	35104	35039	37546	43245
2018	34855	38076	37082	40499	37268	34927	35120	35041	37826	43928
2019	34850	38219	37222	40811	37460	34926	35158	35065	38107	44603
2020	34852	38361	37369	41123	37646	34933	35200	35095	38374	45257

Table H-2 All Fatalities Excluding Motorcycles
Fatality Impacts of Behavioral Programs and Proposed Safety Standards
Change From Base Estimate
<<<<<<<<<<<<<<<<<<**Removed Impacts**>>>>>>>>>>>>>>>>>>>>>>>>

	Base Estimate	Seat Belts	Alcohol Improv.	Combined Behavioral	ESC	Heavy-Truck Brakes	Side Impact	Ejection Mitigation	Proposed Standards	All NHTSA Activities
2005	0	0	0	0	0	0	0	0	0	0
2006	0	0	-291	-291	0	0	0	0	0	-291
2007	0	-415	-479	-898	0	0	0	0	0	-898
2008	0	-799	-662	-1473	-35	0	0	0	-35	-1509
2009	0	-1153	-839	-2016	-129	0	0	0	-129	-2151
2010	0	-1480	-1012	-2529	-258	-6	0	0	-264	-2810
2011	0	-1775	-1178	-3005	-475	-17	0	0	-492	-3535
2012	0	-2043	-1338	-3450	-795	-27	0	0	-822	-4345
2013	0	-2286	-1493	-3868	-1124	-36	-8	-8	-1177	-5162
2014	0	-2506	-1644	-4258	-1427	-44	-48	-38	-1562	-5995
2015	0	-2706	-1791	-4626	-1705	-52	-110	-79	-1957	-6824
2016	0	-2890	-1937	-4978	-1961	-59	-166	-118	-2322	-7611
2017	0	-3061	-2082	-5316	-2196	-65	-218	-153	-2659	-8359
2018	0	-3220	-2227	-5643	-2412	-71	-265	-185	-2970	-9072
2019	0	-3369	-2372	-5962	-2611	-77	-308	-215	-3257	-9754
2020	0	-3509	-2518	-6272	-2794	-82	-348	-243	-3522	-10405

Table I-1 Passenger Vehicles Only
Fatality Impacts of Behavioral Programs and Proposed Safety Standards
<<<<<<<<<<<<<<<<<<**Removed Impacts**>>>>>>>>>>>>>>>>>>>>>>>>>

	Base Estimate	Seat Belts	Alcohol Improv.	Combined Behavioral	ESC	Heavy-Truck Brakes	Side Impact	Ejection Mitigation	Proposed Standards	All NHTSA Activities
2005	31415	31415	31415	31415	31415	31415	31415	31415	31415	31415
2006	31441	31441	31685	31685	31441	31441	31441	31441	31441	31685
2007	30813	31226	31208	31625	30813	30813	30813	30813	30813	31625
2008	30169	30964	30706	31511	30203	30169	30169	30169	30203	31547
2009	29528	30677	30199	31367	29657	29528	29528	29528	29657	31501
2010	28905	30382	29704	31209	29163	28911	28905	28905	29168	31487
2011	28182	29955	29096	30909	28657	28198	28182	28182	28673	31435
2012	27459	29504	28483	30578	28255	27486	27459	27459	28282	31466
2013	26759	29050	27884	30239	27885	26794	26766	26767	27938	31524
2014	26071	28588	27292	29885	27504	26116	26120	26110	27640	31608
2015	25414	28136	26724	29536	27129	25466	25524	25494	27383	31716
2016	24824	27736	26219	29236	26800	24884	24991	24943	27164	31848
2017	24297	27388	25774	28983	26514	24363	24517	24452	26982	32001
2018	23829	27086	25385	28774	26269	23901	24097	24017	26833	32176
2019	23416	26830	25047	28608	26062	23493	23728	23634	26717	32370
2020	23053	26617	24758	28482	25891	23136	23406	23300	26630	32583

Table I-2 Passenger Vehicles Only
Fatality Impacts of Behavioral Programs and Proposed Safety Standards
Change From Base Estimate
<<<<<<<<<<<<<<<<<<**Removed Impacts**>>>>>>>>>>>>>>>>>>>>>>>>>

	Base Estimate	Seat Belts	Alcohol Improv.	Combined Behavioral	ESC	Heavy-Truck Brakes	Side Impact	Ejection Mitigation	Proposed Standards	All NHTSA Activities
2005	0	0	0	0	0	0	0	0	0	0
2006	0	0	-244	-244	0	0	0	0	0	-244
2007	0	-412	-395	-811	0	0	0	0	0	-811
2008	0	-795	-538	-1343	-35	0	0	0	-35	-1379
2009	0	-1149	-671	-1839	-129	0	0	0	-129	-1973
2010	0	-1477	-798	-2303	-257	-6	0	0	-263	-2581
2011	0	-1774	-915	-2728	-475	-17	0	0	-492	-3253
2012	0	-2044	-1024	-3119	-795	-27	0	0	-823	-4007
2013	0	-2291	-1125	-3481	-1126	-36	-8	-8	-1180	-4766
2014	0	-2516	-1220	-3814	-1432	-44	-48	-38	-1568	-5537
2015	0	-2722	-1310	-4122	-1715	-52	-110	-80	-1969	-6302
2016	0	-2912	-1395	-4412	-1976	-59	-167	-118	-2340	-7024
2017	0	-3090	-1477	-4685	-2217	-66	-220	-154	-2684	-7704
2018	0	-3257	-1555	-4945	-2440	-72	-268	-187	-3004	-8346
2019	0	-3415	-1632	-5192	-2646	-78	-312	-218	-3301	-8954
2020	0	-3564	-1705	-5429	-2837	-83	-353	-247	-3577	-9530

Table J-1 Passenger Vehicles and Motorcycles
Fatality Impacts of Behavioral Programs and Proposed Safety Standards
<<<<<<<<<<<<<<<<<<<**Removed Impacts**>>>>>>>>>>>>>>>>>>>>>>>>>>

	Base Estimate	Seat Belts	Alcohol Improv.	Combined Behavioral	ESC	Heavy-Truck Brakes	Side Impact	Ejection Mitigation	Proposed Standards	All NHTSA Activities
2005	35968	35968	35968	35968	35968	35968	35968	35968	35968	35968
2006	36216	36216	36459	36459	36216	36216	36216	36216	36216	36459
2007	35750	36162	36149	36566	35750	35750	35750	35750	35750	36566
2008	35198	35991	35751	36556	35233	35198	35198	35198	35233	36592
2009	34578	35723	35279	36446	34707	34578	34578	34578	34707	36581
2010	33902	35372	34748	36253	34158	33908	33902	33902	34164	36531
2011	33053	34816	34038	35850	33525	33070	33053	33053	33542	36376
2012	32139	34169	33257	35353	32929	32165	32139	32139	32956	36240
2013	31188	33461	32437	34792	32305	31224	31196	31197	32359	36077
2014	30205	32697	31580	34173	31623	30249	30253	30243	31758	35896
2015	29218	31909	30716	33528	30913	29269	29327	29297	31165	35709
2016	28279	31155	29900	32917	30230	28338	28445	28396	30590	35529
2017	27401	30447	29144	32352	29585	27466	27617	27553	30047	35371
2018	26593	29798	28459	31848	28993	26664	26857	26778	29549	35250
2019	25867	29221	27857	31417	28465	25943	26174	26082	29109	35179
2020	25232	28727	27346	31070	28012	25313	25579	25475	28739	35171

Table J-2 Passenger Vehicles and Motorcycles
Fatality Impacts of Behavioral Programs and Proposed Safety Standards
Change From Base Estimate
<<<<<<<<<<<<<<<<<<<**Removed Impacts**>>>>>>>>>>>>>>>>>>>>>>>>>>

	Base Estimate	Seat Belts	Alcohol Improv.	Combined Behavioral	ESC	Heavy-Truck Brakes	Side Impact	Ejection Mitigation	Proposed Standards	All NHTSA Activities
2005	0	0	0	0	0	0	0	0	0	0
2006	0	0	-243	-243	0	0	0	0	0	-243
2007	0	-412	-400	-816	0	0	0	0	0	-816
2008	0	-793	-552	-1357	-35	0	0	0	-35	-1393
2009	0	-1145	-700	-1868	-128	0	0	0	-128	-2002
2010	0	-1470	-846	-2351	-256	-6	0	0	-262	-2629
2011	0	-1763	-985	-2797	-472	-17	0	0	-489	-3323
2012	0	-2030	-1118	-3214	-790	-26	0	0	-817	-4101
2013	0	-2272	-1248	-3604	-1117	-36	-8	-8	-1170	-4889
2014	0	-2492	-1375	-3968	-1419	-44	-48	-38	-1553	-5691
2015	0	-2691	-1498	-4311	-1695	-52	-109	-79	-1947	-6491
2016	0	-2876	-1621	-4638	-1950	-59	-165	-117	-2310	-7250
2017	0	-3046	-1743	-4952	-2185	-65	-217	-152	-2646	-7971
2018	0	-3206	-1866	-5256	-2400	-71	-264	-185	-2956	-8657
2019	0	-3355	-1990	-5551	-2598	-76	-307	-215	-3242	-9313
2020	0	-3495	-2114	-5838	-2780	-81	-347	-243	-3507	-9939

Table K-1 Nonoccupants
Fatality Impacts of Behavioral Programs and Proposed Safety Standards
<<<<<<<<<<<<<<<<<<**Removed Impacts**>>>>>>>>>>>>>>>>>>>>>>>>>

	Base Estimate	Seat Belts	Alcohol Improv.	Combined Behavioral	ESC	Heavy-Truck Brakes	Side Impact	Ejection Mitigation	Proposed Standards	All NHTSA Activities
2005	5849	5849	5849	5849	5849	5849	5849	5849	5849	5849
2006	5893	5893	5937	5937	5893	5893	5893	5893	5893	5937
2007	5953	5953	6026	6026	5953	5953	5953	5953	5953	6026
2008	6015	6015	6116	6116	6015	6015	6015	6015	6015	6116
2009	6079	6079	6208	6208	6079	6079	6079	6079	6079	6208
2010	6144	6144	6301	6301	6144	6144	6144	6144	6144	6301
2011	6211	6211	6396	6396	6211	6211	6211	6211	6211	6396
2012	6280	6280	6491	6491	6280	6280	6280	6280	6280	6491
2013	6351	6351	6589	6589	6351	6351	6351	6351	6351	6589
2014	6423	6423	6688	6688	6423	6423	6423	6423	6423	6688
2015	6497	6497	6788	6788	6497	6497	6497	6497	6497	6788
2016	6573	6573	6890	6890	6573	6573	6573	6573	6573	6890
2017	6651	6651	6993	6993	6651	6651	6651	6651	6651	6993
2018	6730	6730	7098	7098	6730	6730	6730	6730	6730	7098
2019	6812	6812	7205	7205	6812	6812	6812	6812	6812	7205
2020	6895	6895	7313	7313	6895	6895	6895	6895	6895	7313

Table K-2 Nonoccupants
Fatality Impacts of Behavioral Programs and Proposed Safety Standards
Change From Base Estimate
<<<<<<<<<<<<<<<<<<**Removed Impacts**>>>>>>>>>>>>>>>>>>>>>>>>>

	Base Estimate	Seat Belts	Alcohol Improv.	Combined Behavioral	ESC	Heavy-Truck Brakes	Side Impact	Ejection Mitigation	Proposed Standards	All NHTSA Activities
2005	0	0	0	0	0	0	0	0	0	0
2006	0	0	-44	-44	0	0	0	0	0	-44
2007	0	0	-73	-73	0	0	0	0	0	-73
2008	0	0	-101	-101	0	0	0	0	0	-101
2009	0	0	-129	-129	0	0	0	0	0	-129
2010	0	0	-157	-157	0	0	0	0	0	-157
2011	0	0	-184	-184	0	0	0	0	0	-184
2012	0	0	-212	-212	0	0	0	0	0	-212
2013	0	0	-238	-238	0	0	0	0	0	-238
2014	0	0	-265	-265	0	0	0	0	0	-265
2015	0	0	-291	-291	0	0	0	0	0	-291
2016	0	0	-317	-317	0	0	0	0	0	-317
2017	0	0	-343	-343	0	0	0	0	0	-343
2018	0	0	-368	-368	0	0	0	0	0	-368
2019	0	0	-393	-393	0	0	0	0	0	-393
2020	0	0	-418	-418	0	0	0	0	0	-418

Table L-1
Summary of Fatality Rate Estimates for
Selected Fatality Rate Measures
Base Scenario*

	All Fatalities	Passenger Vehicles	Non-occupants	Motorcycles
2005	1.45	1.14	0.20	0.73
2006	1.44	1.13	0.19	0.75
2007	1.41	1.09	0.19	0.76
2008	1.37	1.05	0.19	0.76
2009	1.34	1.01	0.19	0.77
2010	1.30	0.98	0.19	0.78
2011	1.27	0.94	0.19	0.78
2012	1.23	0.90	0.19	0.78
2013	1.20	0.86	0.19	0.78
2014	1.16	0.83	0.19	0.77
2015	1.13	0.80	0.19	0.75
2016	1.10	0.77	0.19	0.73
2017	1.08	0.74	0.19	0.71
2018	1.06	0.71	0.19	0.68
2019	1.03	0.69	0.18	0.64
2020	1.01	0.67	0.18	0.61

*Assumes continued progress at historical pace for seat belt use and alcohol impairment, and generational cycle for motorcycle fatality surge.

Table L-2
Summary of Fatality Rate Estimates for
Selected Fatality Rate Measures
Modest Seat Belt Progress Scenario*

	All Fatalities	Passenger Vehicles	Non-occupants	Motorcycles
2005	1.45	1.14	0.20	0.73
2006	1.44	1.13	0.19	0.75
2007	1.41	1.10	0.19	0.76
2008	1.38	1.06	0.19	0.76
2009	1.35	1.03	0.19	0.77
2010	1.32	1.00	0.19	0.78
2011	1.29	0.96	0.19	0.78
2012	1.26	0.93	0.19	0.78
2013	1.23	0.90	0.19	0.78
2014	1.20	0.86	0.19	0.77
2015	1.17	0.83	0.19	0.75
2016	1.14	0.80	0.19	0.73
2017	1.11	0.78	0.19	0.71
2018	1.09	0.75	0.19	0.68
2019	1.07	0.73	0.18	0.64
2020	1.05	0.71	0.18	0.61

* Assumes continued progress at half historical pace for seat belt use.

Table L-3
Summary of Fatality Rate Estimates for
Selected Fatality Rate Measures
Modest Alcohol Progress Scenario*

	All Fatalities	Passenger Vehicles	Non-occupants	Motorcycles
2005	1.45	1.14	0.20	0.73
2006	1.45	1.13	0.19	0.75
2007	1.42	1.09	0.19	0.76
2008	1.38	1.06	0.19	0.76
2009	1.35	1.02	0.19	0.77
2010	1.32	0.99	0.19	0.78
2011	1.28	0.95	0.19	0.78
2012	1.25	0.92	0.19	0.78
2013	1.22	0.88	0.19	0.78
2014	1.19	0.85	0.19	0.77
2015	1.16	0.82	0.19	0.75
2016	1.13	0.79	0.19	0.73
2017	1.10	0.76	0.19	0.71
2018	1.08	0.74	0.19	0.68
2019	1.06	0.72	0.19	0.64
2020	1.04	0.70	0.19	0.61

*Assumes continued progress at half historical pace for alcohol-related fatality reduction.

Table L-4
Summary of Fatality Rate Estimates for
Selected Fatality Rate Measures
Modest Behavioral Scenario*

	All Fatalities	Passenger Vehicles	Non-occupants	Motorcycles
2005	1.45	1.14	0.20	0.73
2006	1.45	1.13	0.19	0.75
2007	1.42	1.10	0.19	0.76
2008	1.40	1.07	0.19	0.76
2009	1.37	1.04	0.19	0.77
2010	1.34	1.01	0.19	0.78
2011	1.31	0.98	0.19	0.78
2012	1.28	0.95	0.19	0.78
2013	1.25	0.92	0.19	0.78
2014	1.22	0.88	0.19	0.77
2015	1.19	0.85	0.19	0.75
2016	1.16	0.83	0.19	0.73
2017	1.14	0.80	0.19	0.71
2018	1.12	0.78	0.19	0.68
2019	1.10	0.76	0.19	0.64
2020	1.08	0.74	0.19	0.61

* Assumes continued progress at half historical pace for both seat belt use and alcohol-related fatality reduction.

Table L-5

Summary of Fatality Rate Estimates for
Selected Fatality Rate Measures
Continuous Motorcycle Fatality Growth Scenario*

	All Fatalities	Passenger Vehicles	Non-occupants	Motorcycles
2005	1.45	1.14	0.20	0.73
2006	1.44	1.13	0.19	0.74
2007	1.41	1.09	0.19	0.76
2008	1.39	1.05	0.19	0.77
2009	1.36	1.01	0.19	0.78
2010	1.33	0.98	0.19	0.79
2011	1.30	0.94	0.19	0.80
2012	1.27	0.90	0.19	0.80
2013	1.24	0.86	0.19	0.81
2014	1.21	0.83	0.19	0.82
2015	1.19	0.80	0.19	0.82
2016	1.16	0.77	0.19	0.83
2017	1.14	0.74	0.19	0.84
2018	1.12	0.71	0.19	0.84
2019	1.10	0.69	0.18	0.85
2020	1.09	0.67	0.18	0.85

*Assumes continued growth of motorcycle fatalities and registrations at previous eight-year average pace.

Table L-6

Summary of Fatality Rate Estimates for
Selected Fatality Rate Measures
Average of Continuous and Generational Motorcycle Growth Scenario*

	All Fatalities	Passenger Vehicles	Non-occupants	Motorcycles
2005	1.45	1.14	0.20	0.73
2006	1.44	1.13	0.19	0.74
2007	1.41	1.09	0.19	0.76
2008	1.38	1.05	0.19	0.76
2009	1.35	1.01	0.19	0.77
2010	1.31	0.98	0.19	0.78
2011	1.28	0.94	0.19	0.79
2012	1.24	0.90	0.19	0.79
2013	1.21	0.86	0.19	0.80
2014	1.18	0.83	0.19	0.80
2015	1.15	0.80	0.19	0.80
2016	1.12	0.77	0.19	0.79
2017	1.09	0.74	0.19	0.79
2018	1.07	0.71	0.19	0.79
2019	1.05	0.69	0.18	0.78
2020	1.03	0.67	0.18	0.78

*Assumes growth of motorcycle fatalities at pace equal to average of that predicted by generational scenario and continuous scenario.

Table L-7
Summary of Fatality Rate Estimates for
Selected Fatality Rate Measures
Probable Worst Case Scenario*

	All Fatalities	Passenger Vehicles	Non-occupants	Motorcycles
2005	1.45	1.14	0.20	0.73
2006	1.45	1.13	0.19	0.74
2007	1.43	1.10	0.19	0.76
2008	1.40	1.07	0.19	0.76
2009	1.38	1.04	0.19	0.77
2010	1.35	1.01	0.19	0.78
2011	1.32	0.98	0.19	0.79
2012	1.29	0.95	0.19	0.79
2013	1.26	0.92	0.19	0.80
2014	1.23	0.88	0.19	0.80
2015	1.20	0.85	0.19	0.80
2016	1.18	0.83	0.19	0.79
2017	1.15	0.80	0.19	0.79
2018	1.13	0.78	0.19	0.79
2019	1.11	0.76	0.19	0.78
2020	1.09	0.74	0.19	0.78

*Assumes growth of motorcycle fatalities at pace equal to average of that predicted by generational scenario and continuous scenario, continued progress at half historical pace for seat belt use, and continued progress at half historical pace for alcohol-related fatality reduction.

DOT HS 810 777
January 2007

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

www.nhtsa.gov