Drilling in Detroit

Tapping Automaker Ingenuity to Build Safe and Efficient Automobiles

Union of Concerned Scientists

David Friedman

Jason Mark

Patricia Monahan

Center for Auto Safety

Carl Nash

Clarence Ditlow

Union of Concerned Scientists

DRILLING IN DETROIT

Tapping Automaker Ingenuity to Build Safe and Efficient Automobiles

David Friedman

Jason Mark

Patricia Monahan

Union of Concerned Scientists

Carl Nash

Clarence Ditlow

Center for Auto Safety

Union of Concerned Scientists

June 2001

David Friedman is a senior analyst in the UCS Clean Vehicles program. **Jason Mark** is the Clean Vehicles program director, and **Patricia Monahan** is a senior analyst in the Clean Vehicles program.

Carl Nash is a consultant and former director of the Office for Strategic Planning and Evaluation at the National Highway Traffic Safety Administration. **Clarence Ditlow** is the executive director of the Center for Auto Safety.

The Union of Concerned Scientists is a nonprofit partnership of scientists and citizens combining rigorous scientific analysis, innovative policy development and effective citizen advocacy to achieve practical environmental solutions.

The UCS Clean Vehicles program focuses on changing current transporation policies, which favor single-occupancy driving and fossil fuels. The program develops and promotes innovative strategies to make transportation less polluting and more energy efficient and provides information to policymakers, the media, and the public about transportation's impact on public health, the environment, and the economy.

More information about UCS and the Clean Vehicles program is available on the UCS website at *www.ucsusa.org/vehicles.*

The full text of this report is available on the UCS website *(www.ucsusa.org/publications)* or may be obtained from

UCS Publications
2 Brattle Square
Cambridge, MA 02238-9105

Or email *pubs@ucsusa.org* or call 617-547-5552.

Printed on recycled paper

CHAPTER 7

SAFETY AND FUEL ECONOMY

Automakers can utilize a variety of design and technology options for reducing fuel consumption. The only one that could have a significant impact on occupant safety during a crash, however, is vehicle weight reduction.[33] The auto industry has argued that weight reduction compromises safety and that public policy should not encourage further fuel economy improvements, since they would lead to vehicle weight reduction (as they did in the period from 1977 through 1985).

Contrary to this assumption, the relationship between safety and the weights of vehicles in the fleet is neither direct nor obvious. The factors that affect public safety on the road are so many and varied that actual road casualties can be only generally predicted. In particular, the concern over the safety of weight reduction is driven by the poor safety performance of the lighter vehicles in the fleet. This performance is misleading since it is partly due to two factors: (1) the lightest vehicles in the fleet tend to be the least expensive and thus incorporate the fewest safety advances, and (2) lighter vehicles tend to be driven by younger, more aggressive drivers.

Vehicle weight reduction is a reasonable strategy for fuel economy improvements if it is applied most aggressively to the SUVs, minivans, and pickup trucks used as private passenger vehicles. In addition, these weight reductions can be applied in combination with obvious and inexpensive safety improvements.

Principles of elementary physics imply that in a two-vehicle collision, a heavier vehicle should be safer than a lighter one. In practice, however, that is not necessarily always the case. In a two-vehicle crash, for example, if the heavier vehicle is struck in the side by the front of a lighter vehicle, the occupants of the heavier vehicle may be more at risk. Further, the potential for survival in

[33] Estimates show that a 10 percent reduction in vehicle weight could result in a 3 to 7 percent increase in fuel economy (NRC 1992; OTA 1991).

single-vehicle crashes (including rollovers) depends on many factors, only one minor one of which is vehicle weight.

When one considers road transportation generally, the difference in weight between vehicles is much more important to occupant safety than the average weight of all vehicles sharing the road. Furthermore, specific design features that affect the inherent safety of individual vehicles and their compatibility when they collide play a more important role than do the weights of the individual vehicles.

Driving on a Highly Skewed Field

When discussing motor vehicle crash losses, it is critical to consider the major shift toward light trucks over the past 25 years. Since half of all new light-duty vehicles are SUVs, pickups, and minivans, the nature of accidents and the spectrum of crashes have changed dramatically.

Some of the popularity of light trucks can be linked to the perception that they are safer than passenger cars and the fact that SUV drivers sit higher, giving them a more commanding view of traffic. While light trucks must meet essentially the same federal motor vehicle safety standards as passenger cars, two areas—rollover safety and compatibility of vehicles in two-vehicle crashes—are not covered or are inadequately covered in these standards. These two areas are critical to the safety of occupants of light trucks and occupants of vehicles that are hit by them.

Rollover Safety

A vehicle's rollover safety is a combination of its rollover propensity, restraint performance in rollovers, and roof strength. SUVs are roughly twice as likely to roll over as passenger cars. The National Highway Transportation Safety Administration recently began to provide static stability index (SSI) consumer information in its New Car Assessment Program on all light motor vehicles.[34] The SSI provides a strong indication of a vehicle's rollover propensity and confirms concerns regarding the rollover safety of many of the heavier vehicles. Federal motor vehicle safety standard (FMVSS) 216 governs roof strength, but the standard is so weak as to be virtually meaningless.[35]

Compatibility in Two-Vehicle Crashes

In two-vehicle collisions, compatibility refers to the degree to which each vehicle minimizes the potential for injury in both vehicles. Weight disparity is a major factor in compatibility, as light trucks are, on average, more than 1,000 pounds heavier than passenger cars.

The second factor in compatibility is the height of the primary structure of a vehicle. Passenger car manufacturers design cars with their primary structure set between 14 and 21 inches above the ground in order to meet federal bumper and side-impact standards. Light trucks are not subject to the bumper standards, and their primary structure is often well above that of passenger cars.[36] Thus, a light truck is likely to override the safety structure of a passenger car in a crash. This is particularly disastrous if a light truck strikes the side of a passenger car.

The third factor in compatibility is that the frames of heavier vehicles such as light trucks are generally stiffer than those of cars. These stiffer frames do not absorb their share of the energy of a crash and thus tend to force the other vehicle to deform more and absorb the majority of the crash energy. These impacts are important in both front and side crashes with all other vehicles on the road.

SUVs in general, and pickups in particular, seriously violate all of the principles of compatibility. On the other hand, the passenger car fleet has been moving toward increased compatibility. In the passenger car fleet, the disparity in vehicle weight has decreased dramatically over the past 25 years. Since the adoption of the CAFE standards, small passenger cars have become heavier while large passenger cars have become lighter, with the biggest growth in the new-car fleet coming in the middle with 3,500-pound cars. These cars went from 12.5 percent of the new-car fleet in 1975 to 51.9 percent in 2000 (Heavenrich and Hellman 2000). For the 1975 model year, cars with inertia weights of less than 2,500 pounds made up 10.8 percent of the new-car fleet but only 2.6 percent in model year 2000. In contrast, passenger cars in the over-4,500-pound weight class and above made up 50 percent of the new-car fleet in 1975 but only 0.9 percent in 2000. The net effect of these changes was a safer passenger car fleet, particularly when one considers the improved safety technology put into passenger cars.

[36] 49 CFR 581, Bumper Standard.

Safety by the Numbers

In 1979, the motor vehicle fleet consisted mostly of vehicles that had been designed before the energy crisis of 1973 to 1974.[37] At that time, light trucks still played a very small part in new-vehicle sales, and smaller vehicles had only begun to make their way into the market. Thus, 1979 provides a reasonable baseline against which to compare the two key trends over the past 20 years: (1) the dramatic increase in passenger car fuel economy and the attendant reduction in average car weight; and (2) the substantial increase in light trucks as a proportion of the total vehicle fleet.

The changes in vehicle registrations are shown in table 17. During that period, the proportion of light trucks in the fleet went from 22 percent to 37 percent. The number of light trucks today is 2.5 times the number of 20 years ago.

Table 17. Approximate Registrations of Various Types of Motor Vehicles in the United States

Year	Passenger Cars (millions)	Light Trucks[a] (millions)	Large Trucks (millions)
1979	103.5	28.9	5.9
1984	112.2	35.3	5.4
1989	122.8	47.1	6.2
1994	122.0	59.5	6.6
1999	126.9	73.1	7.8

a. Light trucks include pickup trucks, sport utility vehicles, and vans.
Source: US Department of Transportation 2000.

Over the last two decades, highway fatalities have gone down by nearly 20 percent, while travel has increased by more than 40 percent—a reduction of more than 50 percent in fatalities per mile traveled over 20 years. During the same period, pedestrian fatalities decreased by one-third, and motorcycle fatalities were cut by half. Passenger-car and light-truck occupant fatalities were down about 10 percent, mostly in single-vehicle, nonrollover crashes. Table 18 shows these and some other basic motor vehicle fleet and crash statistics characterizing the changes.

[37] The first downsized vehicles, full-sized General Motors B and C platform cars, were introduced as 1977 models. They were roughly 1,000 pounds lighter than the vehicles they replaced, but retained the same interior room and performance. It was not until the 1980 model year that a substantial portion of the new American vehicles were genuinely downsized vehicles.

Table 18. A Comparison of Basic US Motor Vehicle Statistics over the Last 20 Years

	1979	1999
Registered Motor Vehicles (% Passenger Cars / % Light Trucks)	144 M (72% / 20%)	212 M (59% / 35%)
Vehicle-Miles Traveled	1.5 billion	2.7 billion
People Killed As Passenger-Car Occupants	27,788	21,164
People Killed As Light-Truck and Van Occupants	7,119	10,647
Pedestrians and Pedalcyclists Killed	9,021	5,981
Heavy-Truck (>10,000 lbs.) Occupants Killed	1,087	936
Motorcycle Riders Killed	4,679	2,284

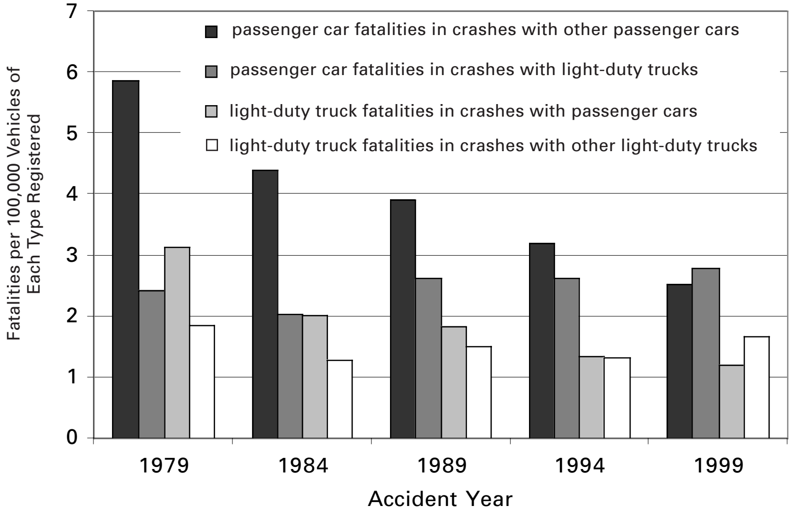
Source: NHTSA' s Fatal Accident Reporting System (FARS).

The reduction in light-vehicle occupant fatalities is a result of a number of factors, including a substantial increase in safety belt use, the almost universal installation of airbags in recent model light motor vehicles, and the implementation of the dynamic side-impact standard. Rollover fatalities have decreased modestly in passenger cars, but they have increased dramatically in pickup trucks and SUVs, consistent with the comparative growth in the number of these vehicles in the fleet. Overall, fatalities in rollovers of pickups and SUVs have more than doubled.

Two-vehicle crashes between passenger cars kill only about half as many people as they did 20 years ago, while fatalities in passenger-car/light-truck crashes have increased by nearly 50 percent. This fact further emphasizes the problem with the current disparity in the vehicles driven on the road today.

Figure 15 shows trends in two-vehicle fatal crashes in terms of the number of deaths for those driving a vehicle per number of registered vehicles of that type on the road (see also table F-1 in appendix F for the actual numbers of fatalities). This figure indicates a fatality risk based on the exposure of each type of vehicle. Had the ratio of light trucks to passenger cars remained as it was in 1979 (22 percent rather than the current 37 percent), nearly 1,000 fewer fatalities would have occurred in two-vehicle crashes between light vehicles.

Figure 15. Occupant Fatality Rates in Crashes Between Two Light-Duty Vehicles per Number of Victim's Type of Vehicles on the Road



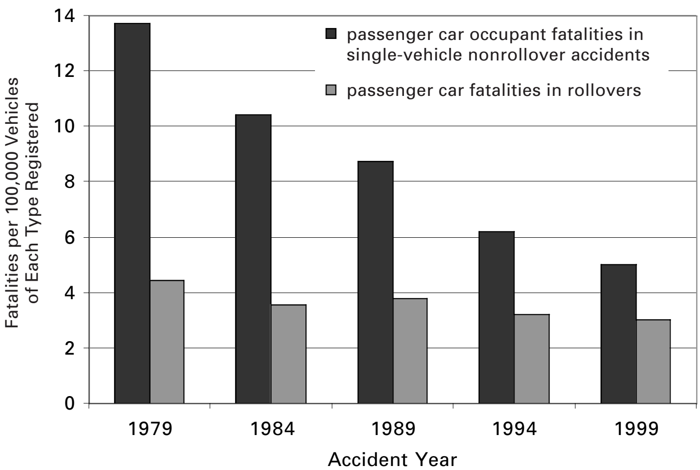
Source: NHTSA's Fatal Accident Reporting System (FARS)

Fatality rates per registered vehicle in single-vehicle crashes show a decline for all vehicles. Differences can be seen, however, for cars versus light trucks (figure 16 and figure 17).[38] The passenger-car nonrollover fatality rate per 100,000 registered passenger cars went from 13.7 in 1979 to 5.0 in 1999 , which represents a reduction in risk of over 60 percent (figure 16). For light trucks and vans, the rate went from 8.1 to 3.9, a reduction of 50 percent. Overall, cars have been making more safety progress in single-vehicle crashes than have light trucks.

In rollover crashes, cars showed an even greater improvement than light trucks. The passenger car fatality rate in a rollover decreased 30 percent, from 4.4 to 3.1, over the same 20 years, while the light-truck and van fatality rate in rollovers went down only half as much, from 6.8 to 5.8. Light-truck and van fatality rates in rollovers were twice as high as were passenger rates in 1999; SUV and pickup rollover rates are even higher.

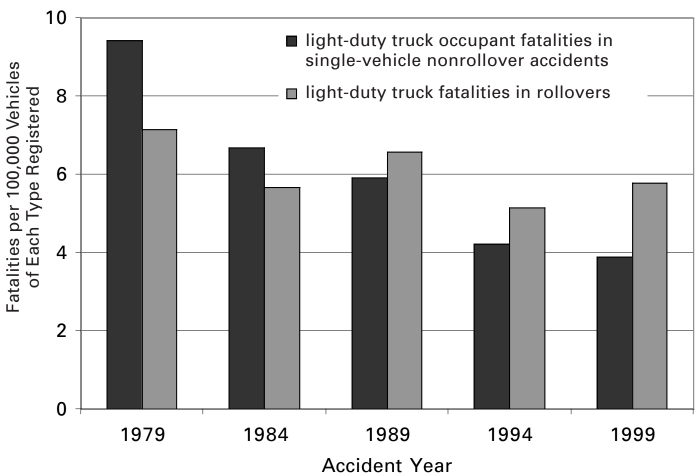
[38] Tables F-2 through F-4 in appendix F show fatalities in single-vehicle crashes of passenger cars, pickups, SUVs, and minivans.

Figure 16. Passenger Car Occupant Fatalities in Single-Vehicle Crashes and Rollovers



Source: NHTSA's Fatal Accident Reporting System (FARS)

Figure 17. Light-Truck Occupant Fatalities in Single-Vehicle Crashes and Rollovers



Source: NHTSA's Fatal Accident Reporting System (FARS)

Rollovers are potentially among the most benign motor vehicle crashes because the forces involved are much lower than the forces in major frontal and side-impact crashes. Approximately half of all serious to fatal casualties in rollovers are from passenger ejection and could be prevented by the virtually universal use of effective safety belts.[39] Many of the remaining casualties result from the collapse and buckling of the vehicle's roof in a rollover. Making adequately strong roofs in new motor vehicles is well within the technological capability of their manufacturers, would add only minimally to the vehicle's weight, and would cost well under $100 per vehicle.

The rate of single-vehicle crash fatalities of all types depends far more on the specific design and use characteristics of vehicles than on their weight. For example, simply increasing safety belt use by 10 percentage points would overwhelm almost any effect of reasonable weight reduction in these types of crashes.

In general, the data on the history of motor vehicle crash losses suggest several conclusions that will help in considering the potential impact of future changes in vehicle fuel economy on safety:

- The major increase in light trucks used as substitutes for passenger cars in the vehicle fleet has kept the number of light-vehicle occupant fatalities from falling as much as other crash statistics. The increased use of light trucks as substitutes for private passenger vehicles has produced at least 2,000 additional rollover fatalities annually.

- Fatalities in single-vehicle crashes went down more than 25 percent from 1979 to 1999, while light-duty vehicle occupant fatalities in two-vehicle crashes went down only about 10 percent. The reduction in single-vehicle crash fatalities was driven by a 45 percent reduction in passenger car single-vehicle crash fatalities, indicating that technologies were adopted that significantly improved vehicle safety. On the other hand, the greater number of light trucks in the US fleet increased passenger-car occupant fatalities in crashes with light trucks by more than 50 percent. This overwhelmed a decrease in passenger-car occupant fatalities in crashes with other passenger cars of under 50 percent. Overall, two-vehicle crashes would have killed nearly 1,000 fewer people without the major increase in light trucks as passenger car substitutes.

[39] Unfortunately, many current safety belts installed in these vehicles perform poorly in rollovers.

- If the disparity in weights between passenger cars and light trucks becomes wider, either because of the design and marketing practices of the automakers or because of continuing regulatory policies that differentially affect cars and light trucks, fatalities in these types of two-vehicle crashes will continue to increase relative to other types of automotive casualties. Reducing this weight disparity is likely to decrease casualties in two-vehicle crashes.

- No more than one out of four light-vehicle occupant fatalities would be influenced by changes in vehicle weight to improve fuel economy. Furthermore, the effect of weight disparity on these fatalities is marginal—almost certainly less than the effect on fatalities of the major increase in light trucks in the fleet. Had light-vehicle occupant fatalities in two-vehicle crashes decreased to the same degree as single-vehicle crash occupant fatalities (other than from rollovers), the effect would have been roughly 2,000 fewer fatalities (less than 5 percent of the total in 1999).

Weight Reduction to Improve Vehicle Fuel Economy

Historical data and the physics of crashes indicate that some crash fatalities are fundamentally dependent on the weights of the vehicles involved while others are not. In two-vehicle crashes, occupants of the lighter vehicle are at a disadvantage, according to past statistics. This effect has been exacerbated by the introduction of large numbers of light trucks into the US vehicle fleet, not only because of the light trucks' greater average weight, but because their structure is stiffer and higher than that of passenger cars. Just as large cars posed more of a hazard to small cars until the former were downsized, so large SUVs pose a hazard to small SUVs and pickups, as well as to all passenger cars.

In the 2000 model year, large SUVs weighing an average 5,439 pounds comprised 5.5 percent of new passenger vehicles (cars, trucks, and vans), while small SUVs were nearly 1,800 pounds lighter, at 3,670 pounds, making up 2.3 percent of the new passenger vehicle fleet. Just as large cars lost nearly 1,400 pounds in weight, from 5,142 pounds to 3,792 between 1975 and 2000, large SUVs could lose a similar amount of weight with a net resultant gain in fleet safety and fuel economy.

Many of the past statistical relationships between weight and crash safety are changing as the science of safety advances. Technologies for high-strength, lightweight materials have been under development by the aluminum and steel industries, both through the Partnership for the Next Generation of Vehicles and through autonomous development programs. The UltraLight Steel Auto Body and Light Truck Structure studies, along with findings from the Auto Aluminum Alliance, have indicated the ability to achieve significant reductions in car and light-truck weight without sacrificing safety (AISI 2001, ULSAB 2001, ULSAB-AVC 2001, Auto Aluminum Alliance 2001). Because these materials maintain strength while reducing weight, past historical data no longer apply, and the potential exists for vehicle weight reductions with improved crash characteristics.

Mass reductions of up to 40 percent have been demonstrated in production and prototype vehicles that rely on aluminum and other lightweight materials for much of the powertrain, vehicle structure, and body. While these lighter vehicles do carry additional costs, they are designed to maintain safety, strength, and durability (Ford 2001). In the late 1990s, both Ford and Chrysler built prototype cars of the size and carrying capacity of the Ford Taurus and Dodge Intrepid that weighed only about 2,000 pounds. These vehicles used aluminum and plastics extensively. Chrysler officials said that their 2,000-pound vehicle could eventually be built at a price equivalent to that of its current Dodge Intrepid because it used less material and because Chrysler had developed techniques that substantially simplified the assembly process for this lighter-weight vehicle.

Lighter Versus Less-Expensive Vehicles

For single-vehicle crashes, some estimates of the effect of weight have compared the performance of smaller, less-expensive cars with that of larger, more-expensive cars. This procedure overestimates the effect of weight reduction, because lighter vehicles are typically less expensive and feature less-sophisticated safety engineering. For example, smaller cars have higher rollover rates, but this is primarily because they have narrower track widths (and therefore lower static stability indices) and shorter wheelbases, not because they are lighter. If a larger vehicle is made lighter through substitution of lighter-weight material, rather than by making the vehicle shorter and narrower, such a large vehicle is not likely to have any greater propensity to roll over than it did with the heavier material.

The same reasoning holds true for single-vehicle nonrollover crashes. The structural performance of a lighter vehicle that retains its basic size and energy-management capability should be as good as that of the heavier vehicle it might replace. These principles were demonstrated more than 20 years ago with the National Highway Traffic Safety Administration's Research Safety Vehicle Program.

In two-vehicle crashes, reducing the weight of the heavier vehicle would reduce casualties in the lighter vehicle without necessarily increasing casualties in the heavier vehicle. Furthermore, in the case of SUVs, the trend is toward using passenger-car platforms for these vehicles. The Ford Escape and Acura MDX are two recent examples that join such vehicles as the Mercedes-Benz M Class, Lexus RX300, Honda CR-V, Toyota RAV4, and Subaru Forester.

Building an SUV on a passenger-car platform has two positive effects. First, it can reduce the weight of the vehicle for a given interior space and carrying capacity. It can also reduce the SUV's aggressivity, the danger the vehicle poses to others on the road. Since changing from a light-truck to a passenger-car platform for an SUV can be a technique for improving fuel economy, this change would increase safety for all vehicle occupants as it increases fuel economy.

Reducing light-vehicle weight is unlikely to have much effect on losses in crashes with large trucks, with cyclists, or with pedestrians, because the discrepancy between the weights of these vehicles and individuals is so great. Table 19 summarizes these conclusions.

Assuming that light trucks and vans remain a major part of the private passenger vehicle fleet, efforts to improve automotive fuel economy through weight reduction can most productively be applied first to these vehicles. This is particularly true for light trucks that are used as substitutes for passenger cars, as opposed to those used as commercial or farm vehicles. The opportunity to improve the fuel economy of light trucks is greater simply because of this class of vehicle's size, weight, and poor fuel economy. Because weight reduction has a more significant impact for light trucks than for cars, this report incorporates larger weight reductions for light trucks. The light truck weight reductions are also phased in earlier, to capitalize on the benefits as early as possible.

Previous Studies of Safety/Fuel Economy Trade-Offs

Many studies of the trade-off between safety and fuel economy assume that manufacturers will reduce the weight of their vehicles

Table 19. Motor Vehicle Crash Fatalities and Changes in the Average Weights of Particular Vehicle Classes

Crash Losses Not Significantly Affected by Vehicle Weight

Large Truck Crashes – 4,000 light-vehicle occupant fatalities
Large Truck Crashes – 730 large-truck occupant fatalities
Pedestrians and Pedalcyclists – 6,000 nonoccupant fatalities
Motorcyclists – 2,300 motorcycle-rider fatalities

Crash Losses in Light Vehicles Not Significantly Affected by Vehicle Weight

Rollovers – 9,000 fatalities
Other single-vehicle crashes – 9,200 fatalities
Passenger car/Passenger car – 3,200 fatalities
Light truck/Light truck – 1,200 fatalities

Crash Losses That May Increase or Decrease with Vehicle Weight

Passenger car/Light truck – 3,500 passenger-car occupant fatalities
Passenger car/Light truck – 860 light-truck and van occupant fatalities

Note: These figures are approximate averages derived from recent Fatal Accident Reporting System files.

to increase fuel economy. They also assume that manufacturers will not take advantage of offsetting technologies for increasing safety when vehicles are made lighter. The fact is that the variables that must be addressed in such a study are too many and too unpredictable to lend themselves to any kind of precise analysis.

In particular, many studies assume that the safety of a downsized full-sized car will be equivalent to the safety of a midsized car of the previous generation, for example. This is not necessarily the case, however, both because the configurations of the two vehicles will be different and because the more expensive full-sized car will probably have fewer design and material compromises than its midsized counterpart.

To improve safety in such crashes, more safety regulations are necessary. One example is the dynamic side-impact standard, FMVSS 214. This standard requires improved occupant safety under test conditions where a 3,000-pound, angled moving barrier impacts a vehicle at 33.5 mph. Under such standards, today's more fuel-efficient cars that tend to weigh less are required to include more safety technology and improvements because of the relatively higher change in velocity they experience in a crash compared with that of larger, luxury cars. In addition, increased consumer information is critical to ensuring that people can make reasonable choices. The National Highway Traffic Safety Administration's New Car Assessment Program (NCAP) should be expanded in scope and the information more widely publicized.

Safety Improvements That Remain to Be Widely Implemented

Under the assumption that safety is a societal priority, motor vehicle manufacturers must address vehicle safety measures independently of fuel economy requirements. Until they do, arguments about the nexus between safety and fuel economy have a hollow ring. A number of simple, inexpensive safety designs and technologies remain to be broadly implemented. These include:

- Effective safety-belt use inducements. Currently, 18,000 people who were not wearing safety belts die each year: 6,000 to 10,000 could be saved by effective belt-use inducements.

- Stronger roofs for rollover protection. Although a majority of casualties of rollovers are still unbelted and ejected, 2,000 belted occupants die annually, mostly because of roof crush. With increased belt use, the number of casualties from roof collapse and buckling is likely to increase as fewer people are ejected in rollovers. This further emphasizes the need to ensure that vehicles have safe roof designs.

- Improved safety belt design and performance, including belt pre-tensioners that trigger on rollover as well as on frontal and side crashes. An additional 3,000 to 5,000 people could be saved by an effective rollover protection system: a strong roof, belt pre-tensioners that trigger on rollover, the interior padding required by a new federal standard, and window curtain air bags.[40]

- Crash avoidance technologies such as smart cruise controls, yaw-control systems, nonpulsing anti-lock brakes, and

[40] Racing car drivers regularly survive very dramatic rollover crashes because they are protected by roll cages, five-point safety belts, and helmets. These features can be effectively emulated in ordinary passenger vehicles with a strong roof, well-designed safety belts that include pre-tensioners that trigger upon rollover, and the padding currently required by FMVSS 201 in head-impact areas. The cost of such improvements should be less than $100 for most new vehicles.

drowsy-driver warnings. New computer and communications technologies should provide major opportunities to reduce the possibility of crashes.

Overall, automakers have many opportunities to pursue an aggressive path of vehicle crash safety improvements. In addition, they can choose a strategy of careful application of vehicle weight reduction, along with the application of safety technology, to ensure that consumers have the option to drive vehicles that are both safe and fuel-efficient.

APPENDIX F

Actual Motor Vehicle Crash Statistics

The following data are fatality counts from the Fatal Accident Reporting System (FARS).

Table F-1a. Passenger Car Fatalities in Two-Vehicle Crashes Between Passenger Cars and Vehicles Listed

Accident Year	Passenger Cars	Pickup Trucks	SUVs	Minivans	Total
1979	6,049	1,929	129	439	8,546
1984	4,917	1,708	156	417	7,198
1989	4,809	2,181	411	643	8,044
1994	3,911	2,268	649	288	7,116
1999	3,199	2,205	911	406	6,721

Table F-1b. Pickup Fatalities in Two-Vehicle Crashes Between Pickup Trucks and Vehicles Listed

Accident Year	Passenger Cars	Pickup Trucks	SUVs	Minivans	Total
1979	684	390	17	43	1,134
1984	559	298	20	65	942
1989	625	416	52	87	1,180
1994	569	464	88	38	1,159
1999	499	538	156	68	1,261

Table F-1c. SUV Fatalities in Two-Vehicle Crashes Between SUVs and Vehicles Listed

Accident Year	Passenger Cars	Pickup Trucks	SUVs	Minivans	Total
1979	60	24	-	4	88
1984	69	21	5	1	96
1989	103	50	4	11	168
1994	163	77	21	8	269
1999	228	164	60	38	490

Table F-1d. Minivan Fatalities in Two-Vehicle Crashes Between Minivans and Vehicles Listed

Accident Year	Passenger Cars	Pick-up Trucks	SUVs	Minivans	Total
1979	157	43	-	10	210
1984	85	37	1	6	129
1989	129	54	10	18	211
1994	72	64	17	12	165
1999	137	121	50	23	331

Table F-2. Single-Vehicle Passenger Car Crash Fatalities

	Nonrollovers		Rollovers		
Accident Year	Non-ejected	Ejected	Restrained	Un-restrained	Ejected
1979	12,356	1,874	111	1,976	2,506
1984	9,918	1,774	126	1,428	2,466
1989	8,973	1,772	702	1,304	2,678
1994	6,275	1,316	1,046	907	1,985
1999	5,305	1,069	1,104	833	1,892

Table F-3. Single-Vehicle Pickup Truck Crash Fatalities

	Nonrollovers		Rollovers		
Accident Year	**Non-ejected**	**Ejected**	**Restrained**	**Un-restrained**	**Ejected**
1979	1,836	385	14	580	930
1984	1,576	354	23	486	944
1989	1,700	504	166	619	1,471
1994	1,520	496	278	445	1,355
1999	1,599	471	382	504	1,527

Table F-4. Single-Vehicle SUV Crash Fatalities

	Nonrollovers		Rollovers		
Accident Year	**Non-ejected**	**Ejected**	**Restrained**	**Un-restrained**	**Ejected**
1979	79	50	20	55	228
1984	94	70	31	61	274
1989	152	76	73	75	399
1994	249	97	183	92	536
1999	354	135	354	230	925

Table F-5. Single-Vehicle Minivan Crash Fatalities

	Nonrollovers		Rollovers		
Accident Year	**Non-ejected**	**Ejected**	**Restrained**	**Un-restrained**	**Ejected**
1979	263	109	9	88	140
1984	206	59	8	55	116
1989	269	91	34	61	193
1994	114	38	49	24	100
1999	212	74	88	46	169