ROLLING OVER ON SAFETY:

THE HIDDEN FAILURES OF BELTS IN ROLLOVER CRASHES

Public Citizen

with C. Tab Turner

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> *"If every SUV driver wore their seat belts we'd save 1,000 lives a year," said Eron Shostek, spokesman for the Alliance of Automobile Manufacturers. "We can make the vehicles safer, which we do, but we need the public to meet us halfway and practice safe driving methods."*[1]

Whenever the growing carnage from rollover crashes is raised in the media or by Congress, the auto industry blames drivers and the failure to use safety belts as the source of highway fatalities.[2] But as this report documents, the focus on belt usage, and rising belt use rates, requires that we ask an important question: How effective are safety belts in a rollover crash and are belts well designed to protect people in rollover crashes?

While we now can say, without question, that using a safety belt is far safer than not using one, the push to increase safety belt use has occurred in the absence of any substantial upgrades in the effectiveness of this technology in rollover crashes. Now that safety belt use rates are at an historic high, it is past time to ask whether belts are as effective as they could and should be in rollover crashes.

This report documents serious inadequacies in current belt design and performance in rollover crashes, where belts are one of the most important safety counter-measures. While frontal air bags, and increasingly side impact air bags, provide crucial protection in those types of crashes — compensating at least in part for any belt inadequacies — in rollover crashes occupants rely primarily upon safety belts to prevent ejection of heads, arms and other body parts or flailing about the inside of a vehicle. Belt failure in rollovers, which can involve spooling out of the belt and other failures, risks great and even fatal harm. It is critical that belts perform effectively in rollover crashes, yet evidence suggests that safety belts are tragically ineffective in many rollover crashes.

Major resources, totaling some $150 million requested for FY 2005 federal spending alone, are devoted to increasing belt usage.[3] Dr. Jeffrey Runge, Administrator of the National Highway Traffic Safety Administration (NHTSA), testified before Congress on Mar. 18, 2004, that increasing belt use was the "single most effective way to reduce traffic fatalities and serious injuries."[4] And when sport utility vehicle (SUV) rollover dangers were highlighted by Congressional hearings in the spring of 2003, automakers responded that belt use, not vehicle safety, should be the focus.[5]

Yet the industry and Bush Administration's statements require a thorough analysis of belt performance in rollover crashes and issuance of a federal motor vehicle safety standard. Rollover deaths are now a full one-third of all occupant fatalities, or over 10,000 each year. When serious injuries are added, the number of people whose lives are forever altered by rollover crashes rises to an astonishing 26,000 each year.

Federal data show that 22,000 people *who were wearing a safety belt* died in rollover crashes in the U.S. between 1992 and 2002.[6]

Thousands of lives are needlessly lost, and devastating injuries experienced, each year in rollover crashes despite occupants' use of safety belts. This report is a call-to-arms for the need for a federal safety standard to dynamically test belts in rollovers, so that they will be properly designed to protect occupants against unnecessary harm.

For 37 years, since the first federal belt safety standard took effect, no federal test of belt performance in rollover crashes has been required. And automakers, despite the growing sales of rollover-prone SUVs and pickup trucks, have done little to address the three terrible, and inter-related, risks of rollover crashes: roof crush, ejection, and safety belt performance failure. Some long-overdue attention is now being focused on roof crush, as federal regulators contemplate a new standard for the first time in over thirty years, and a recent groundbreaking series in *The Detroit News* lays out the public case for a new standard.[7] Officials of NHTSA have also indicated that they are interested in measures to reduce ejection, including side impact head air bag requirements.[8] Yet scant notice has been paid to the need to improve belt performance as a rollover survival measure.

The three risks of rollover – roof crush, ejection, and belt failure – are inter-related hazards that make rollover survival unnecessarily difficult. For example, a weak roof poses its own threat of roof crush that can inflict severe head and neck injury. Roof crush also opens ejection portals by distorting and enlarging window openings and weakening doors, so that the safety belt's failure to hold the occupant in the seat leads to partial ejection of the occupant's body, which can produce very grave and fatal injuries. Because belted occupants are held generally inside the vehicle by the restraint, they are also particularly susceptible to severe head and neck injury from a collapsing roof.

The cardinal principle of vehicle safety design is preservation of the integrity of the vehicle occupant's survival space in a crash. All three of the rollover hazards compromise or destroy this protective envelope around the occupant, which should remain intact as a basic safeguard in every kind of crash. A comprehensive solution which addresses all three aspects of the rollover problem is required, and has been proposed in legislation now before Congress.

The bipartisan McCain-Hollings-Snowe-DeWine vehicle safety provisions in Title IV of S.1072, the Safe, Accountable, Flexible, and Efficient Transportation Equity Act of 2003 (SAFETEA), would prevent thousands of needless deaths on the highway each year by requiring NHTSA to issue new safety standards for ejection mitigation and rollover crashworthiness, including an evaluation of safety belts, rollover pretensioners, advanced window safety glass and a new roof crush standard, among other provisions. While the Administration has come out in opposition to the bill despite its timeliness and reasonableness, the flexible, comprehensive approach it embodies would dramatically improve the public's chance of surviving rollover and other crashes.

Thousands of innocent lives would be saved, and tens of thousands of injuries prevented annually, by measures in the bill:

- **A new roof crush resistance standard:** 1,400 deaths and 2,300 severe injuries, including paraplegia and quadriplegia, could be prevented each year by a more stringent standard.[9]
- **Improved head protection and side air bags:** 1,200 lives could be saved, and 975 serious head injuries prevented, each year by a new requirement.[10]
- **Side window glazing ("safety glass"):** A requirement would save 1,305 lives and prevent 575 major injuries each year.[11]
- **Upgrade to standard for door locks and latches:** An upgrade would help to prevent hundreds of the 2,500 door-related ejection deaths each year.[12]
- **Rollover prevention standard that evaluates the use of electronic stability control (ESC):** Studies estimate ESC reduces deaths and injuries by as much as *one-third* by preventing crashes from occurring. The technology could save as many as 2,100 lives a year in rollover crashes alone.[13]
- **Compatibility rules for light trucks:** NHTSA estimates 1,000 lives a year could be saved.[14]
- **Stronger seatback design:** 400 lives could be saved and 1,000 serious injuries prevented, each year.[15]
- **Effective seat belt reminders in all seats:** 900 lives each year could be saved by such a requirement.[16]
- **Applying new vehicle safety standards to vehicles up to 10,000 lbs.:** This extension to cover large SUVs and pickups would save hundreds of lives. Some safety standards, such as the one for roof crush resistance, currently apply only to vehicles below 6,000 lbs., omitting dangerous vehicles.

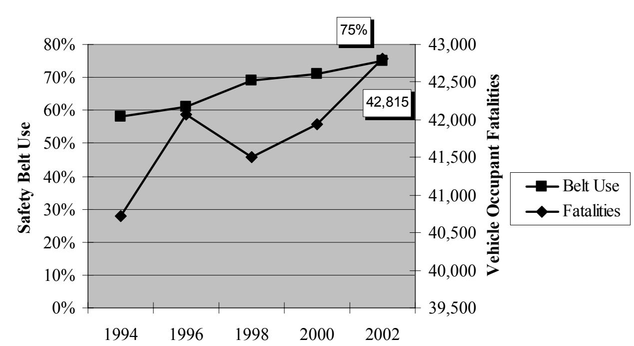
Without a mandate from Congress, these issues could continue to drag on indefinitely, while more people remain at risk. NHTSA still has not issued a proposed or final rule on roof crush protection improvements since it requested comments in 2001, after thirty years of delay.[17] And in 2002, the agency actually withdrew a proposal to improve side window glazing, which would have greatly reduced ejection from side windows.[18] As grieving families find out after it is too late, better safety design in vehicles would save lives. The time for action is now.

I. EXECUTIVE SUMMARY: SAFETY BELTS FAIL TO PROTECT PEOPLE IN ROLLOVER CRASHES

After years of abysmal safety belt use rates, belt use rose dramatically over the past decade with the passage of state belt use laws and improved enforcement. Belt use is currently at its highest level ever – the latest government surveys estimate 79 percent use among Americans.[19] Yet, as the chart below demonstrates, rising belt use is occurring alongside rising numbers of motor vehicle fatalities. In 2002, 42,815 Americans were killed in motor vehicle crashes, an increase of 1.5 percent from the previous year and the highest fatality count in more than a decade.[20]

Overall death rates per 100,000 vehicles are declining, and increased safety belt use is unquestionably a significant contributor to that decline, recorded in figure B. But these declines have flattened out in recent years, and a crucial question is whether we are missing out on further opportunities to save lives due to the failure of belts to perform as well as they should in rollover crashes.

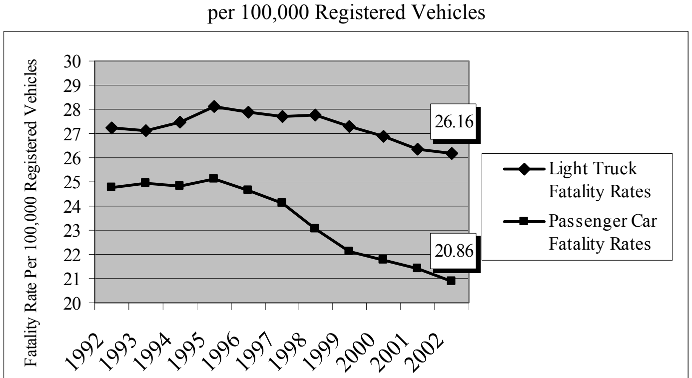
Figure A: Rising Safety Belt Use and Occupant Fatalities



Data source: National Center for Statistical Analysis, National Highway Traffic Safety Administration, *Traffic Safety Facts 2002* Early Edition (DOT HS 809 620), Washington: NHTSA, 2003. 15, 40. and: Glassbrenner, Dona. NCSA, *Safety Belt Use in 2003* (DOT HS 809 646), Washington: NHTSA, Sept. 2003. 12.

Figure B: Passenger Vehicle Occupant Fatality Rates

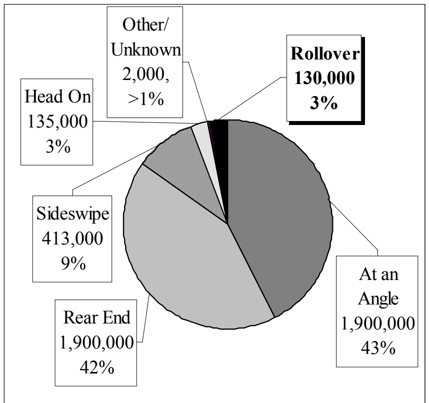
per 100,000 Registered Vehicles



Source: National Center for Statistics and Analysis, National Highway Traffic Safety Administration, *Traffic Safety Facts 2002* (DOT HS 809 620), Washington, DC: NHTSA, Jan. 2004. 17.

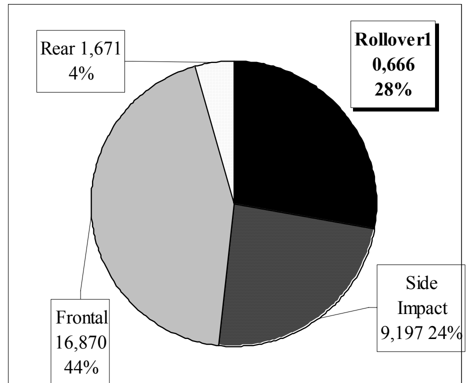
The amazing death toll in rollovers actually results from a small proportion of the overall number of crashes. Only 3 percent of crashes are rollovers, yet rollover crashes are responsible for a full *third* of all vehicle occupant fatalities[21] — now totaling more than 10,000 fatalities each year.[22]

Figure C: Rollovers and Collisions with Other Vehicles in 2002



Data Source: National Center for Statistics and Analysis, National Highway Traffic Safety Administration, *Traffic Safety Facts 2002* (DOT HS 809 620), Washington, DC: NHTSA, Jan. 2004. 54

Figure D: Occupant Fatalities in 2002 by Crash Type



Data Source: National Center for Statistics and Analysis, National Highway Traffic Safety Administration, *Occupant Fatalities in Vehicles with Rollover by Year, Restraint Use, Ejection, and Vehicle Body Type. FARS 1991-2001 FINAL & 2002 ARF*, Washington: National Center for Statistics and Analysis, Sept.

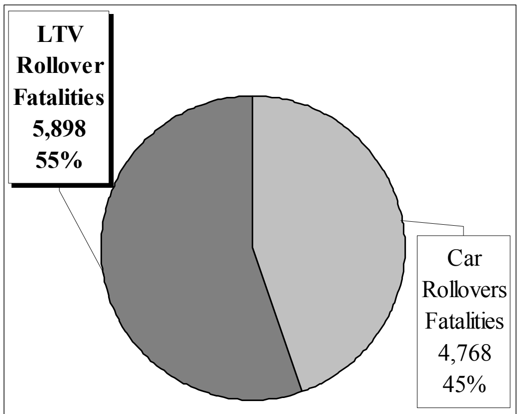
And the numbers are growing. Passenger vehicle fatalities in rollovers increased between 2001 and 2002 and were 82 percent of the increase in all fatalities between those two years.[23] According to the Fatality Analysis Reporting System (FARS) data for 1997 to 2001, 21 percent of all occupants seriously injured and a third of all those killed were in rollover crashes.[24]

Since the revelations about the Ford-Firestone tragedy and the subsequent signing of the Transportation, Recall Enhancement, Accountability and Documentation (TREAD) Act in November 2000, an estimated 31,000 people have died in rollover crashes — *150 times the number of people killed in the Ford-Firestone incident*.

Tragically, these rising fatalities illustrate only part of the gruesome picture: passenger vehicle rollovers lead to 90,000 injured occupants annually.[25] By the late 1990s, rollover crashes were inflicting 12,000 head injuries every year, about 3,000 spinal cord injuries, and annually leaving 500 occupants quadriplegics for life.[26] Overall, 27 percent of all harm in rollovers involves the head and neck, an area in which injury often has severe and deadly consequences.[27]

A sales explosion of rollover-prone light trucks has reversed the trend of declining highway fatalities, despite rising belt use.[28] Between 1988 and 2003, the market share of new SUVs increased by 17 percent, while the market share for passenger cars decreased by approximately the same amount. Light trucks — a category including SUVs and pickup trucks, as well as vans and minivans — while now half of all new passenger vehicle sales, are still only 35 percent of the on-road vehicle fleet, meaning that light trucks are over-represented in rollover deaths, where they incur 55 percent of the fatalities.[29]

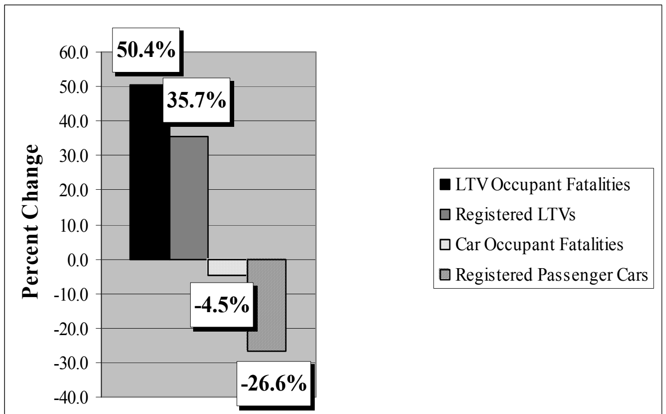
Figure E: Passenger Car and Light Truck Rollover Fatalities in 2002



Data Source: National Center for Statistics and Analysis. Occupant Fatalities in Vehicles with Rollover by Year, Restraint Use, Ejection, and Vehicle Body Type. FARS 1991-2001 FINAL & 2002ARF, Washington: National Center for Statistics and Analysis, Sept. 2003.

Figure F: Change in Occupant Fatalities and Registered Vehicle Population for Passenger Cars and Light Trucks

Comparison: 1992 and 2002 data



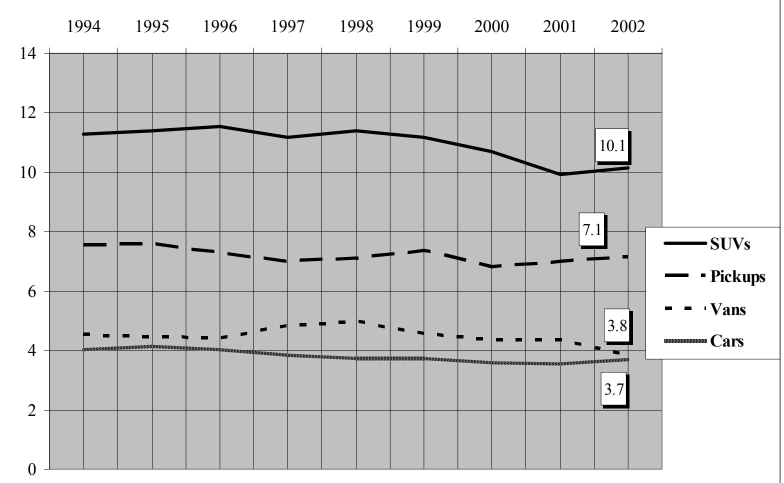
Data Source: National Center for Statistics and Analysis, National Highway Traffic Safety Administration, *Traffic Safety Facts 2002* (DOT HS 809 620), Washington, DC: NHTSA, Jan. 2004. 17,18.

As **Figure F** illustrates, light truck fatalities are increasing even when their increasing share of the vehicle population is taken into account. While over the past decade, the light truck population increased by over 35 percent, light truck occupant fatalities increased over the same period by more than *half*. (Another important observation is that car occupant fatalities have only decreased 4.5 percent in the past decade, despite the fact that the current passenger car population is only two-thirds of what it was ten years ago. This strongly indicates that light truck "aggressiveness," or vehicle mismatch in multiple-vehicle crashes, is seriously undermining improvements in car occupant safety.[30])

Despite their popularity, SUVs pose unreasonably high rollover risks for occupants. Sixty-one percent of SUV occupant fatalities occur in rollover crashes.[31] According to NHTSA, SUVs roll over in fatal crashes three times as often as passenger cars.[32] SUV rollover fatalities have quadrupled over the past decade and a half.[33] Between 2001 and 2002 alone, the number of SUV occupants killed in rollover crashes increased by over 13 percent.[34]

Figure G: Passenger Vehicle Occupant Fatality Rates in Rollovers

per 100,000 registered vehicles

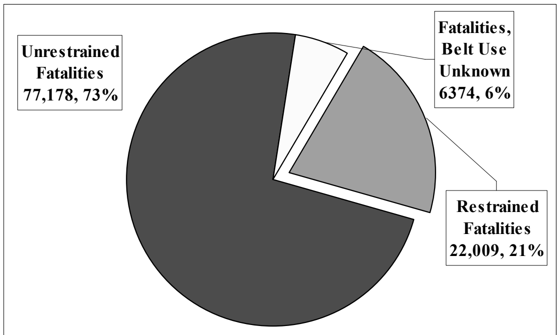


Data Source: National Center for Statistics and Analysis, National Highway Traffic Safety Administration, *2002 Annual Assessment of Motor Vehicle Crashes*, Washington, DC: NHTSA, July 2003. http://www-nrd.nhtsa.dot.gov/2002annual_assessment/toc.htm.

As shown by the chart above, the fatality rate of SUV occupants is 2.5 times that of passenger car occupants who experience a rollover. Similarly, pickup truck occupants are slightly less than twice as likely to die in a rollover as the occupants of a passenger car.[35]

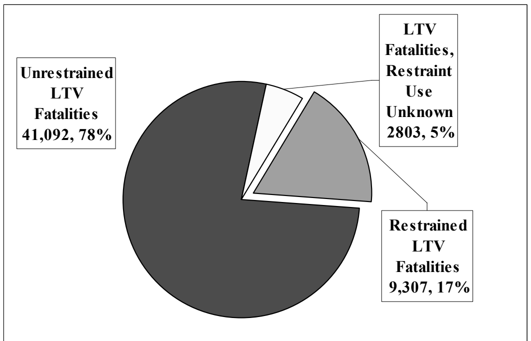
Safety belts are not doing what they should to prevent such deaths and injuries. As the charts below demonstrate, 21 percent of the people killed in rollover crashes were documented in police reports as restrained by safety belts at the time of the crash.

Figure G: Restraint Status of All Rollover Fatalities 1992-2002



Data Source: National Center for Statistics and Analysis, National Highway Traffic Safety Administration, *Occupant Fatalities in Vehicles with Rollover by Year, Person Type, Restraint Use, Ejection, and Vehicle Body Type. FARS 1992-2001 FINAL & 2002 ARF*, Washington: NHTSA, Sept. 2003.

Figure H: Restraint Status of Light Truck Rollover Fatalities 1992-2002



Data Source: National Center for Statistics and Analysis, National Highway Traffic Safety Administration, *Occupant Fatalities in Vehicles with Rollover by Year, Person Type, Restraint Use, Ejection, and Vehicle Body Type. FARS 1992-2001 FINAL & 2002 ARF*, Washington: NHTSA, Sept. 2003.

Federal data show that **22,000 people** who were wearing a safety belt died in rollover crashes in the U.S. between 1992 and 2002.[36]

Between 1992 and 2002, an average of 10,000 lives were lost annually due to rollover crashes — over 2,000 of those rollover deaths each year involved persons who were using their safety belts. What kills these people? In general, belted occupants face harm from the other two risks of rollovers: harm from ejection and roof crush. Some 1,600 belted people die each year inside the vehicle from roof crush and other hazards in rollovers, and about 400 more people die when the vehicle they are in rolls over *and they are ejected despite their use of a safety belt*.[37]

A brief study released by NHTSA researcher Maria Ana Eigen in December 2003 on restraint use and ejections in rollover crashes found that only 3 percent of those *completely ejected* from the vehicle were belted. However, the study troublingly also found that *more than 50 percent of partially ejected occupants were belted*. Partial ejections are particularly devastating because parts of an occupant's body, such as heads and arms, can be crushed between the vehicle and pavement as the vehicle rolls. In its research plan on rollovers, published in August 2003, NHTSA noted, "*Fatal injuries from partial ejection can occur even to belted occupants, when their head protrudes outside the window and strikes the ground in a rollover or even the striking vehicle prior to the roll*over."[38]

Roof crush is another major risk to belted occupants in rollover crashes. As the number of belt users increases due to successful enforcement of belt safety laws, the number of belted occupants killed by roof crush has skyrocketed, in part because belts are fairly effective at preventing many complete ejections. As belts retain more people inside the vehicle, the integrity of the occupant compartment, including the strength of the roof, becomes even more critical for survival.

As a 1968 Ford Motor Company engineer observed after analyzing roof crush injury data, "It is obvious that occupants that are restrained in upright positions are more susceptible to injury from a collapsed roof than unrestrained occupants who are free to tumble about the interior of the vehicle. *It seems unjust to penalize people wearing effective restraint systems by exposing them to more severe injuries than they might expect with no restraints*."

In fact, rising belt use has more than tripled the number of belted roof crush victims in the last ten years. Each year, there are 6,900 rollovers in which roof crush occurs, and in 3,700 of these rollovers the vehicle occupants are belted.[39] While only 16 percent of the people injured in rollover crashes were belted a decade ago, NHTSA estimates that *belted occupants now represent 55 percent of deaths and injuries in roof-crush (non-ejection), rollover cases*.[40]

With improved safety design, rollovers could be highly survivable crashes because the forces in the collision are generally are spread out over a much longer time-frame than, for instance, in a frontal collision. Race car drivers, who wear five-point belts and drive vehicles with strong roll cages and other crash protections, can walk away from high speed rollover crashes that would be deadly in other vehicles because of the superior crashworthiness designed into race cars.

> Scott McClellan, executive vice president of Independent Witness, a Salt Lake City safety research firm that has been equipping NASCAR vehicles with safety instrumentation for the past 2 1/2 years, said "I can't recall a rollover or flip that resulted in a serious injury. . . *If the occupant compartment integrity is maintained, the potential for injury is pretty low*."[41]

This suggests that rollovers are primarily dangerous due to poor vehicle design. Seat structures and safety belts are not designed to keep occupants in place during a crash, and vehicle roofs are so weak that they collapse, crushing occupants' heads and spines and inflicting serious or fatal injuries. As a result, the side and windshield glass breaks, providing ejection portals and further weakening the roof and side structure.

While ejection, roof crush and seat strength are key issues, the purpose of this report is to take a closer look at a long-neglected subject: safety belt performance in rollover crashes. Amazingly, in its 37 years as the nation's safety agency, NHTSA has not yet seriously examined this critical issue. The agency's safety belt research plan, released in August 2003, concentrated exclusively on increasing belt use. NHTSA's rollover plan, also released in August 2003, acknowledged that "current safety belts have the potential to allow significant body motion during some rollovers," but only gave vague promises of future testing to address the problem, providing no solid deadlines or specific proposals for fixing current belt deficiencies.[42]

This report, which examines the crashworthiness of vehicles in rollovers, reveals the following belt-related failures:

- Current standard belt systems do not adequately hold the occupant in the seat structure thus permitting lateral (side-to-side) and vertical (up-and-down) movement of an occupant's head and body during a rollover, which allows contact with the roof or vehicle roof support pillars, or partial ejection of the occupant's head and body through the side window or door, with devastating results.

- Most current belt systems lack rollover pretensioners (a belt feature that is designed to automatically remove slack in the belt) and fail to pull slack in quickly enough to prevent occupants from repeatedly slamming their head and bodies against hard vehicle interior or exterior surfaces.

- Most belt straps are anchored to the frame next to the occupant's shoulder instead of the seat. Therefore, when the vehicle's frame is deformed during a rollover crash, the effectiveness of the shoulder strap to restrain the occupant can be destroyed or compromised because the belt angles are altered, slack is allowed to develop, and, in some instances, the belt is rendered non-operational.

- Lap belts are typically anchored behind the occupant's hips, rather than directly below the hips. Due to this poor belt geometry, the belt wraps up around the occupant at an angle that is less effective at controlling the occupant's movement upwards, towards the roof in a roll, than if the belt wrapped vertically and up over the occupant's lap.

- Some safety belt buckles are susceptible to unlatching during rollovers, which occurs when crash forces or an impact unlock the belt buckle, rendering the occupant completely without the benefit of a belt.

In the absence of federal oversight or regulation, automakers continue to install old, inadequate belt systems that fail to protect occupants during rollovers. In light of the escalating number of rollover fatalities and the significant evidence that safety belts are not protecting occupants during rollovers, we urge Congress to enact, and NHTSA to issue, comprehensive rollover crashworthiness standards to improve the performance of safety belts in rollovers.

Congressional action is appropriate and necessary because NHTSA's history on these issues is one of delay, obfuscation and broken promises. Although charged by Congress to prepare a rollover propensity minimum standard in 1991, NHTSA terminated its rulemaking on the standard in 1994 after intense auto industry pressure. NHTSA defended the termination by citing obsolete statistics on the number of SUVs in the vehicle population in the late 1980s, without acknowledging the growing popularity and hazards of this vehicle class. At that time, NHTSA promised that a consumer information program and numerous rollover crashworthiness protections would be forthcoming. None of the crashworthiness provisions that were promised, including roof crush standards, seatback strength standards and safety belt standards, has been issued.

"If you look at the things we promised [on rollover], then you're right, we didn't put out," Stephen Kratzke, NHTSA's associate administrator for safety performance standards, told *The Detroit News* in a story published in April 2004. "It's fair enough to hold us accountable for that."[43]

These long-overdue safety needs, and the need for greater accountability for NHTSA, are being answered by the bipartisan safety provisions included in SAFETEA, the Highway Bill S.1072, as passed by the Senate in February, 2004. The provisions, authored by Sen. John McCain (R-Ariz.) and Sen. Ernest Hollings (D-S.C.), offer major safety improvements, including the following:

- A rollover resistance standard that will require performance improvements in rollover-prone vehicles and support the use and further development of technologies to improve roll resistance and vehicle handling, such as electronic stability control.

- A roof strength standard — emphasizing a dynamic test — to prevent extensive roof collapse, which can measure injuries to people in evolving crash situations and evaluate safety belt performance in rollovers.

- A rollover crashworthiness standard, including improved seat structure, safety belt design (with safety belt pretensioners that tighten in a rollover crash), side impact airbags and roof padding protection, all of which will dramatically increase rollover survivability.

- An ejection mitigation standard using a combination of safety technologies, including advanced safety side window glazing, side window curtain airbags and side impact airbags.

- An upgraded door lock and retention standard to reduce door openings in rollovers and other crashes and prevent ejection.

The major feature of Title IV is its acknowledgment that addressing rollover and other risks requires a comprehensive approach to inter-related aspects of vehicle design. While the bill does not address the details of these performance standards, it does set reasonable deadlines for final action. By allowing the agency and industry to compress re-design costs on a set schedule, it will create jobs in safety technology and other fields while minimizing costs for consumers. In most areas, both the agency and industry have known of the need for action, and the intolerable costs of delay, for more than thirty years. The bill presents a series of feasible and long-overdue solutions that would save thousands of lives each year. It is long past time for NHTSA and the auto industry use this knowledge to save lives.

For more information on this important bill, read our report, *Keeping the Safety in SAFETEA: Life-Saving Vehicle Safety Provisions Are Long-Overdue and Feasible*, at http://www.citizen.org/autosafety/legislation/tea3/articles.cfm?ID=11275

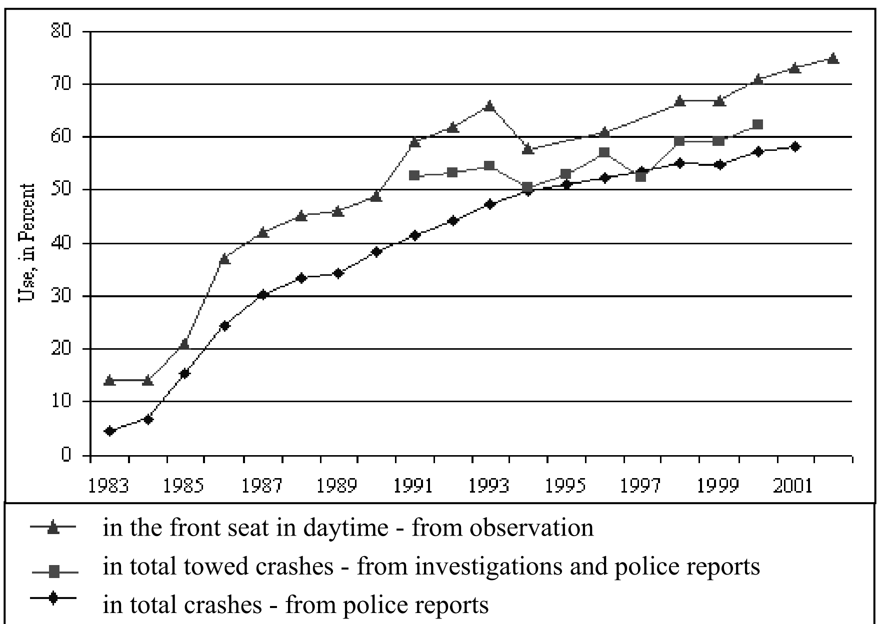
II. THE ANATOMY OF SAFETY BELT FAILURE IN ROLLOVERS

Government and auto industry rhetoric both correctly identify belt use as a critical element of safety for people in rollover crashes, but neither recognizes the significant problems with belt effectiveness. As more and more Americans wear their safety belts, increasing numbers of rollover deaths involve belted occupants, making an understanding of belt failure in rollovers critical.

A. Safety Belt Use Rates Are on the Rise, But Data on Rollover Crashes and Belts Raise Troubling Questions

Since the 1980s, more and more Americans buckle up before driving. In 1983, only 14 percent of passenger vehicle occupants wore their safety belt.[44] Ten years later, the estimated percentage of national belt use had risen dramatically to more than 60 percent. Currently, belt use for front seat vehicle occupants is at an historic high of 79 percent.[45]

Figure I: Belt Use Trends*



* Among occupants, ages 5 and older, of passenger vehicles observed or reported to have been belted or unbelted.

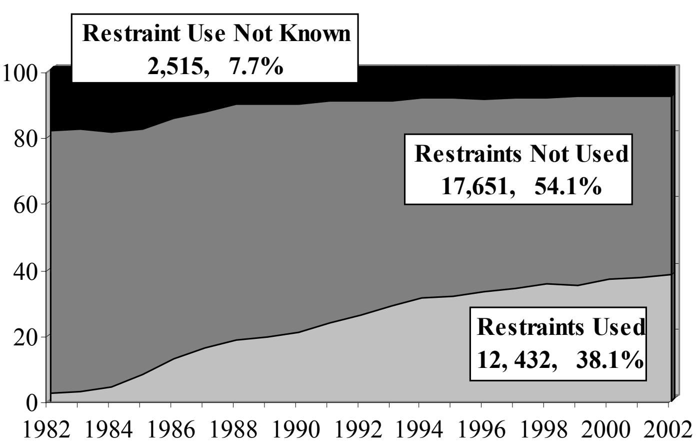
Date Source: National Highway Traffic Safety Administration. *Initiatives to Address the Safety Belt Use*, Washington, DC: National Highway Traffic Safety Administration, July 2003.

This change is the result of various safety standards, public education campaigns and enforcement efforts, the inclusion of lap/shoulder safety belts in all new vehicles beginning with 1968 models, years of government public relations and state police enforcement efforts, and passage of state-level safety belt use laws, including essential primary enforcement belt laws, which allow a ticket to be issued for failure to buckle up without any other traffic infraction, in 21 states.[46] States with primary belt laws have the highest belt use rates, such as California at 91 percent, and Washington state at 95 percent.[47] Unfortunately, the U.S. Senate in February, 2004, on the SAFETEA Highway Bill, S. 1072, voted down, by a vote of 56 to 42, an amendment sponsored by Senators John Warner (R.-Va.) and Hilary Clinton (D.-N.Y.) which would have pushed states to enact primary belt use laws with further incentives and, eventually, withholding of highway funds.

As the chart above suggests, however, overall belt use rates vary based on the method of recording and whether the data is gathered during normal vehicle operation or in a crash. Police records regarding belt usage in fatal crashes show numbers substantially lower than that of the general population in daytime observation surveys. While nationwide belt usage is observed at almost 80 percent, occupant belt usage in all fatal crashes in 2002 was less than 40 percent.[48]

This may be due in part to differences in the usage of belts by daytime versus nighttime drivers, and to the higher-risk behavior of those people within the driving population that tend to be involved in fatal crashes. For example, 41 percent of fatal crashes are alcohol related; a quarter of these alcohol-related crashes occur between midnight and 3 a.m.[49]

Figure J: Changing Percentage of Belt Use Among Occupant Fatalities



Data Source: National Center for Statistics and Analysis, National Highway Traffic Safety Administration, *Traffic Safety Facts 2002* (DOT HS 809 620), Washington: NHTSA, 2003. 40.

Moreover, as shown above, for a small percentage of fatal crash victims, belt use status is "unknown." According to 1992-2002 data from the government's Fatality Analysis Reporting System (FARS) — the most complete source of fatal crash data in the country — belt use was unknown for 6 percent of rollover occupant fatalities.[50]

It is important to note that ineffective safety belts, as detailed below, may distort the data on belt usage in both subtle and obvious ways, particularly in the case of light trucks, including SUVs, and in rollover crashes. There are some significant discrepancies in the data. For example, the average belt use in fatal rollover crashes is 21 percent, considerably lower than the average in other fatal crash types, or 36 percent.[51] While the exact reasons for this are uncertain, it may be a result of belt unlatching in rollovers, spooling out to permit ejection, or other safety belt flaws, which cause the occupant to be recorded by police reports as unrestrained despite belt use prior to the crash.

The source for a major federal database on fatal crashes is police reports, which can vary in depth and detail from state to state and even county by county. In some cases, belt use may be unrecorded if a belted victim is ejected and did not survive to correct the record, which could contribute to significant under-reporting of belt failure.

Moreover, there is a troubling discrepancy between recorded belt use in fatal SUV rollovers and fatal passenger car rollovers. While the recorded belt use of SUV occupants killed in rollovers is 17, recorded belt use of passenger car rollover fatalities is much higher, at 24 percent.[52] These discrepancies have no correlation with the average observed belt use of SUV and passenger car occupants. SUV occupants' average belt use is actually slightly higher than the average for passenger car occupants — 83 percent, compared to 81 percent.[53]

Therefore, it is imperative that researchers further examine the causes of the low recorded belt use for SUV rollover fatality victims. Such discrepancies suggest that occupants in fact come out of safety belts during a crash due to the poor performance of restraint systems in rollovers. The high death rates in SUVs may be an indication that SUV occupants are doubly exposed to harm. While we have long known that they are far more likely to be involved in a rollover crash, these disturbing data suggest that SUV occupants may also be considerably more vulnerable to inadequate belt performance, and the much higher risk of injury and death that results.

Both the government and the auto industry frequently rely on hypothetical statistics about the fatality-reducing potential of increased belt use. For example, instead of addressing SUV safety head-on following increased criticism about their risks, Eron Shostek, spokesman for the Alliance of Automobile Manufacturers said, "If every SUV driver wore their seat belts we'd save 1,000 lives a year."[54] Though not attributed, this claim appears to be based on a 2000 study in which NHTSA estimated that the safety benefit of achieving 100 percent belt use in the general population would be higher for light truck occupants (yielding a 60 percent reduction in fatalities) than for car occupants (who would experience a 45 percent reduction in deaths).[55]

No country in the world has achieved a 100 percent belt use rate. And, as we point out above, observed use surveys have only a tangential relationship with actual use in fatal crashes, meaning that good vehicle safety design must always be a fundamental part of any injury reduction strategy. By focusing on belt use, and failing to ask whether belts perform in all crashes, such an approach also leaves important questions unanswered.

A closer look at the data reveals that the differential between light trucks and cars is mainly the result of lives saved by the reduction in complete ejections that safety belts do generally provide.[56] Due to the design of light trucks, light truck occupants are 20 percent more likely to be ejected than car occupants.[57]

> Even when adjusted for factors such as safety belt use and the occurrence of rollover, occupants of all light trucks have about 1.4 times greater chance of ejection than do occupants of cars.[58]

Therefore, it is unsurprising that the safety benefit of belts in preventing ejection deaths alone is estimated to be significantly higher for light trucks (32 percent) than for cars (19 percent). When ejection is held aside, belts prevent about the same percent of fatalities within the vehicle for light trucks (28 percent) and cars (26 percent).[59] These results, instead of giving automakers an "out" by blaming consumer behavior, should indicate the need for a more precise analysis of ejection mitigation measures and greater focus on ejection-mitigating vehicle design changes.

Additionally, the fatality statistics used by NHTSA to estimate belt fatality reductions were from 1986-1999, a time during which belt use for light truck occupants was significantly lower than that for cars. Recently, however, SUV and van drivers were observed as having a slightly higher belt use rate than car drivers, as noted above. More up-to-date research that incorporates new trends in light truck registration and belt use is necessary, and would be complementary to analysis on discrepancies between survey record belt use and recorded belt use in fatal crashes.

B. Ejection Risks Plague Belted Occupants as well as the Unbelted

Unbelted Occupants Face Particularly High Risk of Ejection in Rollover Crashes

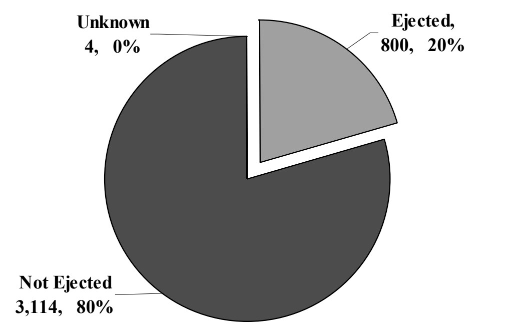
For the unrestrained, the major peril in a rollover crash is ejection. The dynamics of rollover crashes make ejection far more likely for unbelted occupants in rollovers than in other types of crashes. A study of the rollover ejection rate of unbelted individuals shows an eight percent increase, rising from 25 percent to 33 percent, during the 1982-1996 period,[60] and showed that ejections went up as rollover crashes increased. "The main factor contributing to ejection among the unbelted individuals," according to NHTSA, "is the occurrence of rollover during the crash, which increases the odds of ejection over five times." Half of unbelted occupants who die in rollovers were totally ejected from their vehicle, and another 10 percent were partially ejected.[61]

Belted Occupants Are Also at Risk

Research has shown for years that standard safety belt systems fail to effectively restrain occupants' motion in rollover crashes.[62] While safety belts inarguably reduce ejections in rollovers, they do not effectively prevent ejection, as they could with better design.

According to government data for 2002, about 17 percent of belted persons killed in rollover crashes were either totally or partially ejected from their vehicle. SUV occupants fare even worse: About 1 in 5 *belted* sport utility rollover occupant fatalities were totally or partially ejected.[63]

Figure K: Ejection Status of Belted SUV Rollover Fatalities 1992-2002



Data Source: National Center for Statistics and Analysis, National Highway Traffic Safety Administration, *Occupant Fatalities in Vehicles with Rollover by Year, Restraint Use, Ejection, and Vehicle Body Type. FARS 1992-2001 FINAL & 2002 ARF*, Washington: NHTSA, Sept. 2003.

The data reveal another key and surprising discrepancy that indicates belt performance failure in rollover crashes. Although recorded belt use among people fatally injured in rollovers has increased 10 percent just in the last ten years, from 15.6 percent in 1992 to 25.5 percent in 2002, *there has not been a comparable decline in the ejection rate in rollover fatalities.*[64] In fact, the ejection rate of belted people killed in rollovers has improved only one-half of one percent in the same period.[65]

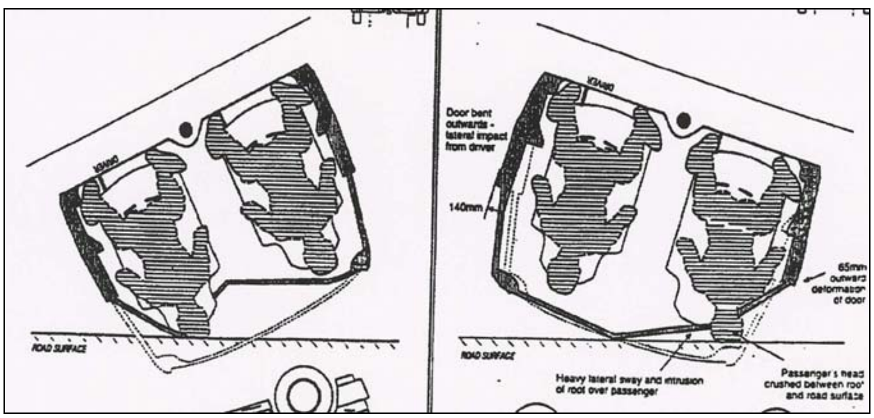
While safety belts reduce a person's chance of *complete* ejection from a vehicle during a rollover, between 1995 and 2001 over 35,000 belted occupants killed in rollover crashes were *partially* ejected.[66]

Partial ejection is very hazardous — and can fling belted occupants against the ground through a side door or window, to be crushed by the vehicle as it rolls. Partial ejection, in all cases involving belted occupants, is the failure of the restraint system to keep a person's body in the seat structure and in place during a rollover crash.[67]

C. Belt Failures Leave Non-Ejected, Belted Occupants in Peril of Roof Crush and Other Hazards

Belted occupants, not unbelted occupants, suffer the majority of non-ejection-related injuries and fatalities. *Six out of ten occupants who suffer serious or fatal injuries in rollovers inside the vehicle are wearing a safety belt*.[68] Ten years ago, belted occupants constituted only 16 percent of rollover fatalities; now, according to NHTSA, over half of the people killed and injured in roof-crush, rollover crashes were wearing their safety belt.[69]

Reasonable protection of occupants in rollover crashes requires a combination of an effective safety belt that holds occupants tightly to the seat and a solid roof structure that does not crush into the survival space where occupants are seated. Even without significant roof crush, belted individuals can sustain substantial head or neck injuries if they are not kept in the seat by the safety belt during a rollover when the roof contacts the ground.

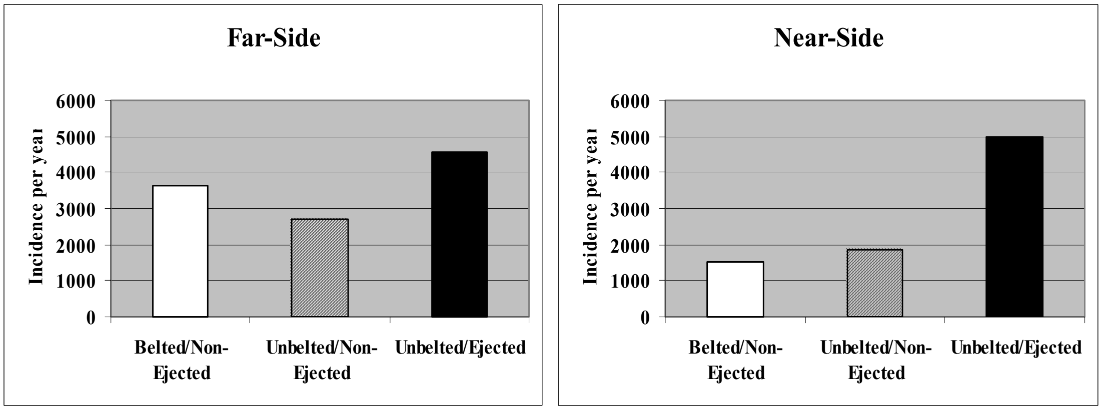


> Every year, 6,500 people sustain one or more serious injuries from roof crush intrusion, and more than half of these people, or 3,450, were buckled up.[70]

The current static standard tests only one side of the vehicle, failing to provide any indication of what will happen in a roll when the far side (rather than the leading side) impacts the ground. But in real-world rollovers, the windshield shatters in the first roll. Once the glass is gone, typically one-third of the roof strength disappears with it, and the roof may crush in. (*See* **Appendix D**.)

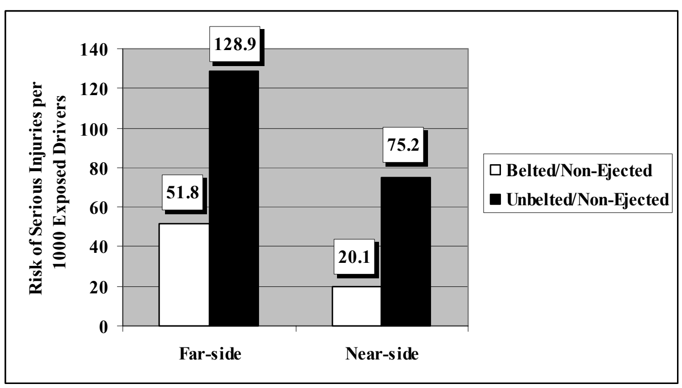
A recent paper by researchers at Delphi Automotive and Saab demonstrates the extraordinary difference in occupant risk depending on the seating position of an occupant relative to the direction of the rollover crash.[71] Occupants on the near, or leading, side of the vehicle — the side towards which the vehicle begins the roll — suffer fewer injuries on average than occupants seated on the far, or trailing, side of the roll. Occupants seated below the second roof impact, or far side of the rollover, suffered a shockingly increased risk of serious injury.[72]

Figure L: Near and Far-Side Serious Injuries (including fatalities)[73]



The disparity in harm suffered by far and near-side occupants demonstrates appalling danger for occupants seated on the far side, even when belted. Unbelted, non-ejected occupants seated on the far side when the vehicle rolls incur **70 percent greater risk** of suffering serious injuries or being killed than unbelted, non-ejected occupants seated on the near side. Moreover, *belted*, non-ejected occupants on the far side suffer **over twice** the risk of serious or fatal injury as suffered by belted, non-ejected occupants on the other side of the rolling vehicle.[74]

Figure M: Far-side Occupants in Rollovers Face Severe Risks of Serious Injuries for Far-Side Roof Crush[75]



Roof impact is responsible for more than 85 percent of serious head injuries suffered by *belted, non-ejected* occupants involved in a rollover. In addition, more than 70 percent of serious spinal injuries experienced in a rollover by belted occupants are caused by impact with the roof.[76] Neck loading, which can result in whiplash and, in some instances, catastrophic neck and spinal injuries, depends on the relative displacement of the torso to the head, which is more sensitive to velocity change than to deceleration.[77] In a rollover crash, velocity can change extremely rapidly — within 80 milliseconds in simulated rollover tests — because rollovers entail both forward and lateral spinning motion, and often involve a series of impacts.[78]

It is therefore imperative that, in order to prevent catastrophic neck injuries, the displacement of the occupant's neck be limited by effective safety belt systems to keep occupants fixed in the seat with proper head restraints and free of contact by the roof or other parts of the vehicle.

D. Research Confirms that Restraints Fail in Rollover Crashes

A wealth of studies by government and independent researchers demonstrate that safety belts allow enough slack and movement for occupants to be hurt by the roof or partially exit the window or door in a rollover. Research performed by James Pywell and his colleagues using rollover tests shows that a conventional safety belt system permits enough vertical and lateral movement to allow a person's head to pass through a broken side door window.[79]

In the late 1990s, former General Motors automotive engineer Donald Friedman demonstrated the failure of three-point safety belts to prevent upward movement of occupants during rollovers. In dynamic tests with a belt system taken from a mid-sized sport utility vehicle, occupants moved between half and three-quarters of a foot vertically before the belts restrained them. Because front seat head clearance averages only a quarter of a foot, safety belt performance leave many vehicle drivers and passengers effectively unrestrained, permitting them to contact the vehicle's roof and upper structure.[80]

Rollover tests performed by government researchers confirmed the results of experts like Friedman, determining that conventional three-point belt systems permitted occupants to rise out of their seat by about half of a foot.[81] That is more than enough excursion to permit occupants to smash their head into a collapsing roof and suffer serious or fatal head and neck trauma.

In its August 2003 report on its plans to address rollovers, NHTSA admitted that safety belts currently have the potential to allow significant body movement during rollovers, but stated that it plans only future tests at an uncertain date.

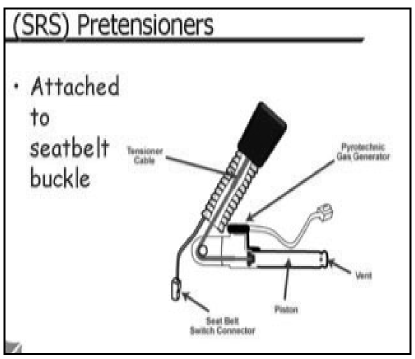
The agency has yet to propose new safety belt standards that specifically reduce neck and spinal injuries during a rollover, such as requiring rollover-sensitive belt pretensioners in all new passenger vehicles.[82] A December 2003 Research Note from NHTSA acknowledged that safety belts have never been designed for rollover crashes:

> Based on previous reporting, the unbelted occupant is the most vulnerable to ejection and fatality; however, even the belted occupant is at risk because some current seatbelts, and most retractors, are primarily designed to withstand the exigencies imposed by a planar [i.e., frontal or side impact] crash.[83]

E. Restraint Systems in Vehicles Stagnate While Essential Technologies for Rollover Protection Stay on the Shelf

Thirty years ago, NHTSA issued safety standards for belts based on simple static laboratory procedures. Although NHTSA has done an admirable job of devoting resources to safety belt use campaigns over the past decade, the agency has not yet closely examined the relevance of the existing belt standards to real-world rollover crash experience. There are numerous on-the-shelf restraint technologies that would significantly improve the performance of existing safety belts in rollovers, but they are not installed in the vast majority of vehicles on the road or in new vehicles. Proposals for various technologies and design changes to upgrade belt performance are described below.

- **Safety belts should include rollover pretensioners to eliminate dangerous amounts of belt slack in a roll.** A pretensioner is a safety device that generates tension forces in the shoulder and/or lap belt immediately (after it is activated by a crash sensing system similar to those currently used for airbag deployment) allowing for rapid removal of safety belt slack in the very early stages of a crash. At the very beginning of a roll, the pretensioners reduce slack in the belt, drawing the occupant towards the seat and away from the roof and vehicle interior.[84]



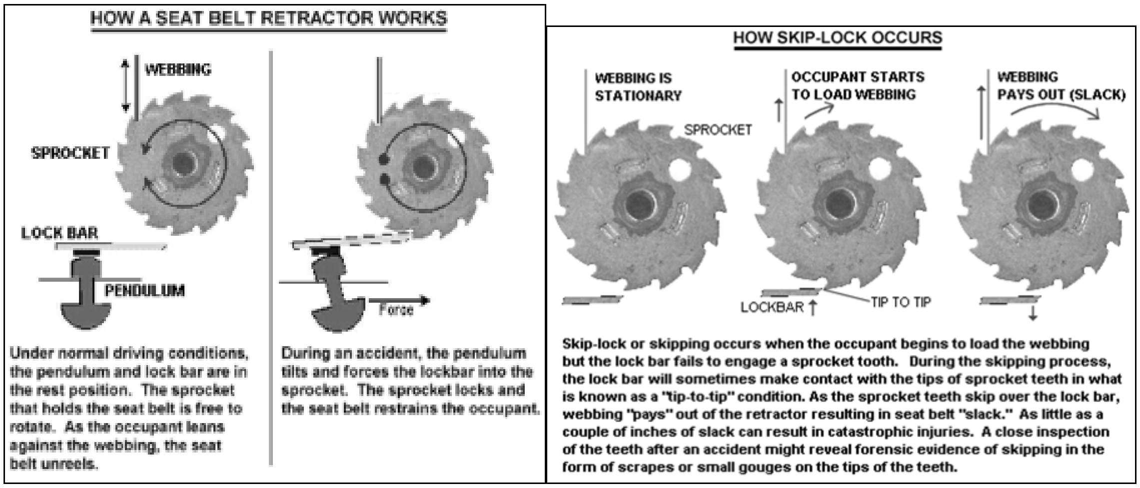
Current production-level safety belts allow a significant amount of upper torso movement that makes occupant contact with the roof, the window, or the A or B pillars of the vehicle "very likely."[85] Emergency locking retractors — the "paws" within the belt system that prevent release of more belt length during a crash — may appear to lock, but they fail to roll up any belt slack that exists before the crash, allowing enough slack that the occupant's head makes contact with the roof.[86]

Simulated rollover tests show that pretensioners can reduce lateral (side-to-side) occupant movement by 15 percent and vertical (up-and-down) occupant movement by 41 percent — effectively limiting much of the motion that causes head injuries. Moreover, pretensioned belts reduce neck movement and loading on occupants by approximately 10 percent.[87]

- **Most vehicles lack rollover sensors to activate safety devices such as pretensioners when the vehicle begins to roll.** For safety devices, such as belt pretensioners and side air bags, to be most effective, they must be triggered by a rollover sensor when a rollover is imminent, before occupants are thrown to the side by the lateral momentum of the roll. Researchers observe that an occupant's body shifts some two to three inches in the first 25 degrees of rotation of a rollover crash,[88] showing the need for a quick response.

  While rollover sensors are a relatively simple technology that has been used in aviation for a long time, only the Volvo XC90 and the Mercedes SL convertible with rollover pop-up bar currently offer a rollover sensor and pretensioner as standard equipment.

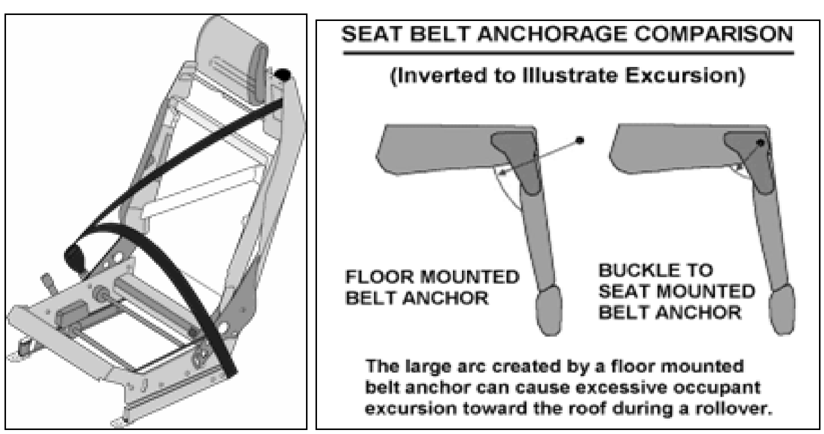
- **Emergency locking retractors must prevent belt "spool out."** A critical aspect of safety belt performance is preventing additional webbing from coming out of the retractor after it locks. However, a variety of belt systems allow belt webbing to spool out during a crash. Additional spool-out of webbing can allow the occupant to strike the interior of the vehicle, or even be fully or partially ejected.



Researcher Mark Arndt carried out studies using production level Emergency Locking Retractors with the vehicle upside down. Although the retractors initially locked in each test, there was a varying degree of subsequent spooling out of the belt webbing, from both rotation of the retractor spool and film spooling, which includes spooling due to simple tightening of the webbing on the retractor. The spooled-out webbing allowed an additional 18-35 mm of displacement of the vehicle occupant.[89]

- **The lap belt anchorage points are too far behind the occupant to effectively keep a person in the seat during a rollover.** Motor vehicle manufacturers anchor safety belts at various locations in the vehicle. The angles created by the location of each anchor point significantly affect belt performance in a rollover crash. Because current lap belt designs are anchored behind the occupant, the belt wraps up around the occupant at an angle that is ineffective at stopping a belted passenger from moving upward when the vehicle is turning upside down.

  Tests show that three-point belt systems with a lap belt anchorage point placed more forward — and therefore under the occupant — decrease the upward occupant motion in rollovers by as much as 75 percent — thus reducing the risk that the occupant is exposed to partial ejection or contact with the roof.[90]

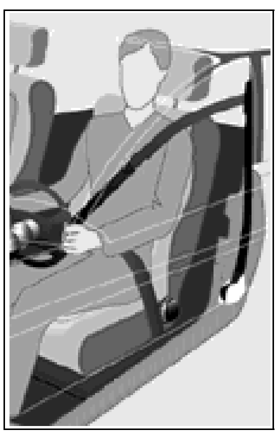


- **Belt buckle locks should be designed to prevent any kind of inertial unlatching.** In addition to the other failures detailed above, some belts completely unlock during a rollover, leaving the occupant without any benefit from the belt at all.

  Inertial unlatching occurs when the safety belt buckle opens due to an impact to the buckle during a crash, whether from a person's hip, a flailing limb, or even just crash forces and poor belt design. Although automakers publicly maintain that inertial unlatching does not occur, more than 150 lock-for-the-latch patents have been issued in attempts to solve this continuing, but unaddressed, problem.[91]

  Because inertial unlatching can be caused by the rigid connections between the buckle and floorboard or seat, merely adding a rubber isolator to the stalk could mitigate this risk. In addition, tests show that preloading of the lap belt decreases the chance that inertial unlatching will occur, suggesting that pretensioners might reduce inertial unlatching.[92]

- **Safety belts should be integrated into the seat to transfer crash energy away from the occupant.** One of the best options to ensure the adequate fit and effectiveness of safety belts is to integrate them into the passenger seat, which often means the seat must be substantially strengthened. In integrated seats, the safety belt components are functionally incorporated into the seat, as opposed to being anchored to the body of the vehicle. This improves the ability of the safety belt system to join the occupant to the seat during a rollover, and conveys crash forces into the vehicle structure rather than the occupant.

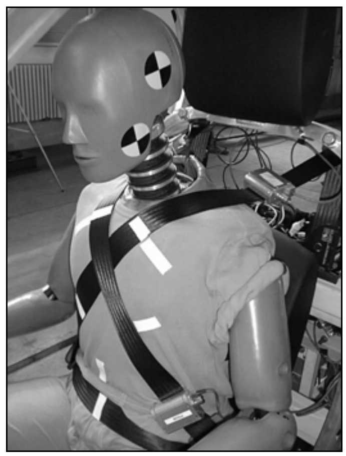


Traditional restraint vs. Integrated restraints

Tests of restraint systems in which the lap and shoulder belts were integrated with the seats demonstrate that integration reduces vertical displacement by 12 percent and lateral head displacement by 13 percent. When a pretensioner was added, the integrated systems demonstrated reductions in vertical and lateral occupant displacement by 63 and 31 percent respectively.[93]

Integrated restraints increase fit and safety, but are standard in only 20 percent of the 2003 model year vehicles examined under the government's New Car Assessment Program, which tests the most widely sold vehicles.[94] *See* **Appendix C.**

- **Four-point safety belts are demonstrably more effective than three-point systems.** Four-point restraints are standard for race car drivers but have yet to make the transition to passenger vehicles, despite their undeniable benefit of more firmly restraining a person's torso in a crash. In early 2001, Ford announced that two new four-point belts were under study, one with two shoulder belts dropping down and connecting to a center belt, the other with two shoulder belts that criss-cross the chest. Neither has been introduced into commercial vehicles to date.[95]



- **A tightened D-ring shoulder belt adjuster reduces occupant movement during a rollover.** The adjustable D-ring is a popular enhancement to belt systems that allows vehicle occupants to adjust the tension and fit of the shoulder belt. Dynamic rollover tests demonstrate that having the D-ring in an upper position, which produces the greatest shoulder belt tension, can reduce vertical head excursion by 8 percent compared to when the D-ring is in a lower position. The upper D-ring position also significantly reduces horizontal and lateral head excursion.[96]

- **Cinching safety belt latch plates reduces occupant movement upwards.** Safety belts with “pass-through” latch plates, used in most vehicles and depicted below, have generally not performed well in simulated rollover “spit” tests and staged rollovers.

Cinching latch plate designs, like the ones used in airplanes that allow passengers to tighten the belt across their laps, do better in rollovers.[97] Studies comparing pass-through and cinching latch plate designs have found that cinching latch plates can provide as much as a six inch reduction in occupant movement upwards.[98]

- **Inflatable safety belts would improve belt performance in rollovers:** Inflatable Tubular Torso Restraint (ITTR), an inflatable section integrated into a shoulder belt portion, is currently available in only a very limited number of vehicles. However, rollover tests with the ITTR show a 60 to 75 percent reduction in horizontal and vertical vehicle occupant excursion compared to use of a standard three-point restraint.[99] This technology was first demonstrated in the 1970s by Chrysler in NHTSA’s Research Safety Vehicle program.

Source: “General ITTR Information Forward-facing Seat Application,” Inflatable Safety Systems, Simula Safety Systems, Inc. http://www.tslaerospace.com/product/simula/PDF/ITTR%20Forward%20Facing%20Flyer.pdf .

V. A History of Government Failure to Address Belt Deficiencies

A. Backpedaling by NHTSA

Federal Auto Safety Agency Removed the Only Requirement in the Rulebook for Rollover Belt Performance

In 1999, after heavy pressure from the auto industry, NHTSA quietly removed part of a standard that had addressed survivability in rollovers prior to that time. Without soliciting any public comment or any announcement of its action, the agency deleted a portion of its 1967 occupant safety standard that stated "A seat belt assembly shall provide pelvic restraint…and the pelvic restraint shall be designed to remain on the pelvis under all conditions, including collision or rollover of the motor vehicle."[100] This deletion was made despite the fact that safety belt performance in rollovers, and the belt position relative to the occupant's pelvis, is critical, and there is no other safety standard that addresses this issue.

According to agency records, the seat belt performance criteria were eliminated at least in part because the auto industry objected to their use in lawsuits brought by injured plaintiffs alleging safety belt and other failures.[101] The industry complained that the standard was not specific enough and that there was no federally mandated rollover crash test to assess safety belt performance. Instead of making the requirement more specific and establishing a rollover crash test to allow manufacturers to verify that vehicles were in compliance, the agency simply edited the safety standard to excise both the industry's obligation to protect occupants in rollovers and the legal basis for challenges to inadequate belt performance.

Despite abundant rollover crash data suggesting serious safety-belt deficiencies, NHTSA has failed to make testing and regulating safety belt effectiveness in rollovers a priority. The agency remains fixated on improving belt use. While it has identified ejection mitigation and roof crush protection as key areas related to rollover safety, it continues to neglect belt performance in rollovers.

Moreover, the agency's regulatory activity contradicts its rhetoric: the agency has yet to issue regulations that would significantly alleviate the risks of either passenger ejection or roof crush in rollovers. The 1971 roof strength standard, which required only a static roof crush test, was, the agency said, a "temporary" measure until NHTSA replaced it with a better test. Since the standard's issuance thirty years ago, the test has never been substantively upgraded.[102]

In addition, in 1989, NHTSA initially proposed applying the roof crush resistance standard to vehicles weighing up to 10,000 lbs., but in its final rule, the agency backed down, leaving vehicles weighing more than 6,000 lbs. — like the Hummer — unregulated for roof crush protection, as the auto industry wished.[103]

In an article in the *Los Angeles Times* last year, NHTSA researchers admitted that belts fail in rollover crashes: "You can slip out of the belt," said Joseph Kanianthra, vehicle safety research chief for NHTSA. "The belts are designed for holding you in place primarily in a frontal collision. In a rollover, suddenly gravity acts against you. The belt can give way and the occupant can go down."[104]

NHTSA still has not issued a proposed or final rule on roof crush protection improvements, on which it requested comments in 2001,[105] and agency officials report that changes will very likely not result in a dynamic test.[106] In 2002, the agency actually withdrew a proposal to improve side window glazing to prevent ejection.[107]

B. Industry Knowledge of Hazards of Belt Failure in Rollovers

The Malibu Tests: GM Takes a Dive

For years, the automotive companies — in particular, General Motors (GM) — have contended that rollover occupants strike, or "dive into," the vehicle roof before any roof crush occurs.[108] This theory suggests that injury is therefore outside the control of the automaker, rather than the product of faulty vehicle design.

The notion that occupants "dive" into the roof raises serious concerns about the failure of belts to prevent occupants from contacting the roof. In addition, internal documents recently released by a judge in the California case *Duan vs. General Motors* show industry knowledge that roof crush actually plays a major role in the serious and fatal injuries suffered by people in vehicles that roll over. They also reveal industry efforts to undermine the federal roof crush protection standard when it was initially developed in 1971. (*See* **Appendix D**). As vehicle safety expert Donald Friedman, a former GM engineer, wrote in his comments to the NHTSA 2001 roof crush request for comments:

"GM's original position, its subsequent research to support that position, and the designs and technologies used to meet the standard have deceived both the agency and the public."[109]

The recently released documents detail, among other things, tests conducted by GM in 1984 with belted human volunteers and dummies in the 1983 Chevrolet Malibu. The vehicles were rotated upside down in order to measure the distance that the belts allowed people inside to fall towards the roof. Shockingly, in this simple inversion test — without the violent impacts and jarring that occur in a rollover — the volunteers' heads, as well as those of the dummies, consistently contacted the roof. . The roof contact occurred despite the fact that both the human volunteers and dummies were belted with standard production safety belts as instructed by the vehicle owner's manual.[110]

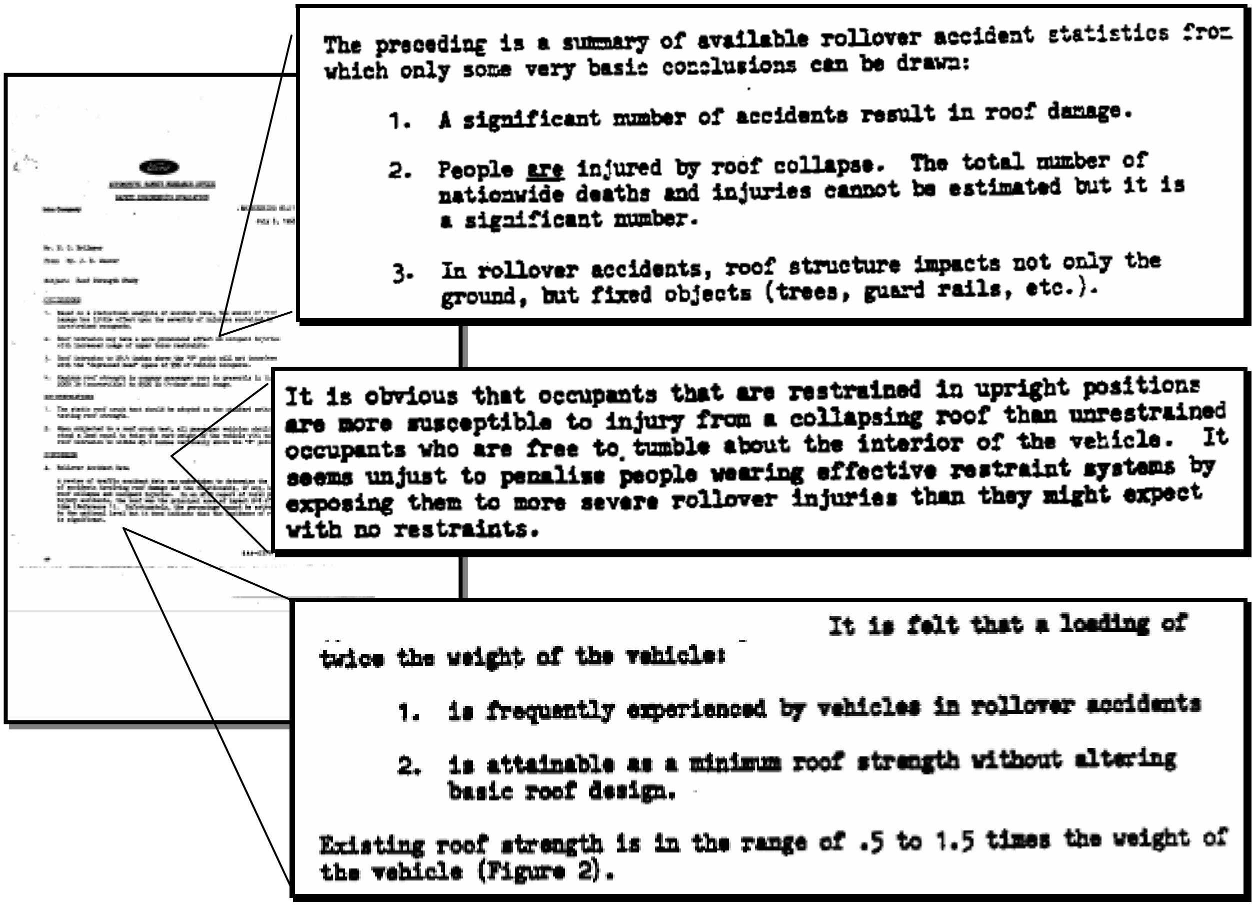
In addition, in 1984 GM conducted a series of lateral dolly tests on 1983 Malibu's. Half of the vehicles were augmented by roll cages and half had no such improvement. All of the vehicles contained dummies restrained with standard, three-point belts adjusted as in the vehicle owner's manual. According to notes of the GM researchers, the belted dummies in both roll caged and non-roll caged vehicles suffered numerous head injuries *because the safety belts failed to prevent the dummies contacting the roof when the roof impacted the ground.*[111]

Other documents released by the court show the industry's own expert testimony raises serious doubts that rollover occupants suffer injuries simply from "diving" into the roof. For example, long-time industry engineer Garry Bahling — co-author of the GM Malibu study that has long been used by the auto industry to defend itself in roof crush cases — admitted in trial testimony that, in his study, no head or neck injuries occurred in non-roll caged vehicles *until after* the roof had begun crushing into the occupant survival space.[112]

Most importantly, the auto industry's diving "tall tale" denying the combination of two deadly failures – roof crush and belt failure – in reality provides no excuse for the lack of decent safety design: **Occupants should never be permitted by safety belt restraints to dive into the roof or any other part of the vehicle in a rollover crash.**

The Weaver Memo and Ford Testing of Roof Strength in the 1960s

Further evidence of long-held industry knowledge of the risks of roof crush, particularly for belted occupants, is contained in a 1968 Safety Engineering Evaluation written by an official of Ford Motor Company. The document contains several key revelations from data available to Ford in the late 1960s.



The preceding is a summary of available rollover accident statistics from which only some very basic conclusions can be drawn:

1. A significant number of accidents result in roof damage.
2. People are injured by roof collapse. The total number of nationwide deaths and injuries cannot be estimated but it is a significant number.
3. In rollover accidents, roof structure impacts not only the ground, but fixed objects (trees, guard rails, etc.).

It is obvious that occupants that are restrained in upright positions are more susceptible to injury from a collapsing roof than unrestrained occupants who are free to tumble about the interior of the vehicle. It seems unjust to penalize people wearing effective restraint systems by exposing them to more severe rollover injuries than they might expect with no restraints.

It is felt that a loading of twice the weight of the vehicle:

1. is frequently experienced by vehicles in rollover accidents
2. is attainable as a minimum roof strength without altering basic roof design.

Existing roof strength is in the range of .5 to 1.5 times the weight of the vehicle (Figure 2).

This final excerpt indicates that, at the time the roof rush resistance standard was finished in 1971, the standard, which requires the roof to withstand only **1.5 times** the vehicle's weight, would have incurred only minimal, if any, improvement in the roof strength of vehicles then on the road. According to the 1968 memo, Ford engineers thought that, at a minimum, a roof crush standard of **2 times** the weight of the vehicle would best reflect the experience of vehicles in rollover crashes and was "attainable. . . without altering basic roof design."

Retired Ford engineers now admit that the company knew of the risks in 1968. Peter Bertelson, the former manager of Ford's Impact Dynamics Department, told *The Detroit News* that the company, "dropped 40 or 42 different cars on their roofs in 1968…The engineers who worked for me were just shocked. The roof strength was terrible."[113]

According to *The Detroit News:* "Bertelson, who has testified in several lawsuits, looks back on Ford's early roof strength tests and questions why a federal safety standard written in the 1970s is still on the books. 'It's long overdue,' he said, '**this has been on my conscience for 30 years.**'"[114]

IV. How to Improve Belt Performance in Rollovers

A. NHTSA Should Act to Fix Belt Performance in Rollovers

There is a wide selection of technologies already available from automotive suppliers that would reduce rollover deaths and injuries. Manufacturers could and should install the following feasible and cost-effective safety technologies and simple design changes in new vehicles:

- Pretensioners to secure occupants to the seat and eliminate belt slack;
- Rollover sensors to activate safety features as soon as a vehicle begins to roll;
- Emergency locking retractors to prevent "spool out;"
- Adjusted lap belt anchorage points to reduce occupant movement;
- Belt buckles designed to prevent unlatching in a crash;
- Restraints integrated into the seat to better absorb crash energy;
- Four-point belt restraints;
- Tightened D-ring shoulder belt adjusters;
- Cinching safety belt latch plates; and
- Inflatable tubular safety belts.

B. Beyond the Belt: NHTSA Should Act Quickly to Address the Other Growing Risks of Rollover Crashes

The current shortcomings of safety belt systems are compounded by vehicle design deficiencies, especially overly flimsy roofs and insufficient side door and window integrity, that make rollover crashes especially — and unnecessarily — dangerous. S.1072 includes safety provisions that would address many of these outstanding crashworthiness problems.

Rollover Propensity Minimum Standard Needed

A meaningful federal action to reduce rollover propensity has been delayed for more than three decades. *See* **Appendix B**.

Beginning with model year 2004 vehicles, NHTSA has included dynamic rollover propensity testing in the NCAP program, under the mandate of the 2000 TREAD Act. But the agency does not test all vehicles, does not advertise the consumer information tests outside of its Web site, and does not have a minimum safety standard to be met before a vehicle can be sold. The agency should use its authority to require manufacturers to test all vehicles and mandate a minimum performance rollover standard for all new vehicles sold.

Electronic stability control (ESC) is an active safety system that helps drivers to maintain control of the vehicle and stay on the road. The system's sensors compare the vehicle's behavior in relation to the steering wheel position. When ESC detects a discrepancy, it intervenes to bring the vehicle's direction back into line by transmitting the right commands to the antilock braking system and sometimes reducing the engine torque.

The core benefit of systems such as ESC is increased driver control, which translates into crash prevention. Studies conducted by DEKRA Automotive Research, DaimlerChrysler, Toyota, the University of Iowa and others indicate that ESC could positively influence *as much as 25 to 43 percent of fatal rollover crashes in the U.S.,* not to mention lives saved other crash types. One study showed a 27-percent reduction in fatalities in single-vehicle rollover crashes when vehicles had ESC, meaning that installing ESC in all vehicles could save more than 2,100 lives in the U.S. annually in rollovers alone, *not* including fatalities that could be prevented in other types of crashes.

Provisions in S.1072 would mandate a rollover prevention minimum standard to increase vehicle resistance to rollover and would publish the government's crash testing results at the point-of-sale, where they are far more useful for consumers. NHTSA would also be required to evaluate additional technologies to improve handling and reduce vehicle instability, including electronic stability control systems.

Dynamic Testing for Rollover Crashworthiness is Feasible and Far Superior to Static Testing

The only current federal test related to rollover crashworthiness is the static roof crush test, which measures the impact of force on only one side of the roof through the steady exertion of pressure. *But a dynamic test is critical because it can measure injury to the occupants and more accurately assess vehicle performance in a crash.* Dynamic drop tests for roof strength are repeatable, as a 2002 Society of Automotive Engineers (SAE) paper attests:

> The automotive industry and researchers have used drop testing for years to evaluate roof strength. In the late 1960s's, SAE developed a standardized procedure to perform full vehicle inverted drop testing. Many domestic and import auto manufacturers have utilized the inverted drop test technique as far back as the 1960s and 1970s to evaluate roof strength....Mercedes-Benz continues to use inverted drop testing as one of their many standard crash tests and has recommended inverted drop tests in its comments to the docket regarding roof strength rulemaking.[115]

The Alliance of Automobile Manufacturers has called any version of dynamic rollover tests "hopelessly unrepeatable,"[116] yet not only are dynamic rollover tests possible and repeatable, but European automakers like Mercedes-Benz, BMW, and Volkswagen and Volvo already test vehicle roof strength using dynamic tests in which the vehicles are rolled off a moving dolly to simulate a real-world rollover.[117] These tests have been conducted to determine vehicle performance despite the lack of an adequate dummy, suggesting that federal regulators could also conduct meaningful dynamic tests pending development of a more accurate dummy.

A rollover dynamic testing device called the Jordan Rollover System (JRS), located in Salinas, California, illustrated below, demonstrates the feasibility of repeatable dynamic rollover tests. The road surface moves along the track, contacting the roof of the vehicle as it rotates on the spit. The test surface impacts *both sides of the roof on the single run*, imitating the first roll of a vehicle in a rollover crash. A second test of the same vehicle would show the additional damage from a second roll.

A Repeatable, Dynamic Rollover Test

While NHTSA officials, in a March 18, 2004, Congressional hearing, told Members of Congress that dynamic tests for rollover were not repeatable, the agency's own 2003 research plan on rollovers states that NHTSA has actually been conducting dynamic rollover tests:

> NHTSA has also been examining ejection potential by using a Dynamic Rollover Fixture, which can simulate rollover conditions and evaluate occupant kinematics, injury mechanisms, and evaluate the performance of restraint systems and ejection countermeasures.[118]

Title IV of S.1072 would require issuance of rollover crashworthiness standards for passenger vehicles under 10,000 lbs. GVWR. The rule would require NHTSA to develop a roof strength standard and to consider a rule based on dynamic tests that realistically duplicate actual forces in a rollover crash (without an instrumented dummy until one is adequately developed). In addition, the rulemaking would consider improved seat structure and safety belt design — including seat belt pretensioners — side impact head protection airbags, and roof injury protection measures. Finally, S.1072 safety provisions would require NHTSA to implement a consumer information program relating to child safety in rollover crashes.

An Adequate Dummy Should Be Developed for Accurate Testing of Rollover Injuries

There is currently no test dummy specifically for rollovers comparable to the Hybrid-III for frontal crashes, or the SID, EUROSID, and BioSID dummies for side impacts.[119] The Hybrid-III is the most widely accepted dummy for automotive crash testing in the world, but it was designed to perform primarily in frontal crashes and the dummy's neck is too stiff and not sufficiently biofidelic (life-like) to provide meaningful data in rollover tests.

Tests comparing the downward travel and timing of the human head with that of the Hybrid-III demonstrate a dramatic disparity between their performances. The human head travels farther downward and over a longer period of time, meaning that rollover tests using the Hybrid-III underestimate the vertical displacement of a vehicle occupant's head and therefore understate potential head and neck injuries.[120]

The agency should develop test dummies that accurately test for rollover injuries in both adults and children. The safety provisions of S.1072 require the agency to report to Congress on efforts to develop a child dummy for use in simulated rollover crashes.

Roof Crush Risks Must Be Addressed by New Crashworthiness Safety Standards

Roof strength is absolutely critical to rollover occupant safety and compounds the risks of safety belt failure. If the vehicle has a weak roof, in a rollover, the occupants risk being crushed to death when the roof collapses, regardless of belt use or performance. If a vehicle has a strong roof but faulty belt system, in a rollover the vehicle's occupants risk contact with the vehicle's interior and ejection.

Thousands of rollover deaths and serious injuries a year involve roof crush, and over half of the victims are buckled up.[121] Integrating a roll cage into the vehicle roof structure could cost less than $30 a vehicle.[122] Rounding vehicle roof edges to lessen the chance of hard roof impact — like Volvo has done in the new XC90[123] — and adding more substantial interior roof padding, could further alleviate an occupant's risks of injury in a rollover.

Roof crush is especially devastating due to inadequate interior padding of the roof. Despite the fact that roof contact is the cause of the overwhelming majority of head injuries suffered by belted occupants in rollover crashes, NHTSA does not require interior impact testing which would adequately address rollover head-to-roof contact or more effective padding of this critical area of the interior.

NHTSA proposed in 1970 to require padding on the vehicle interior, including the roof.[124] However, in 1979 the agency ended this rulemaking, citing as a reason the agency's limited resources.[125] NHTSA projects have demonstrated the potential safety benefits of more substantial vehicle interior padding with the Research Safety Vehicle (RSV) program of the 1970s. The RSVs offered interior padding considerably thicker than that offered in standard passenger vehicles, and this padding significantly contributed to the vehicles' *50 mpg frontal crash protection* — better than any vehicle on the road today. Despite the many millions invested and notable achievements, NHTSA Administrator Jerry Curry destroyed the research vehicles in the early 1990's, and the agency's current rhetoric completely ignores the safety accomplishments of the RSV program.[126]

In 1991, NHTSA was given an opportunity to issue rulemaking ensuring adequate roof padding when Congress passed the Intermodal Surface Transportation Efficiency Act (ISTEA), which included a requirement for a rule to "improve[] head impact protection from interior components of passenger cars (i.e. roof rails, pillars, and front headers"). However, since the final law did not *explicitly* require NHTSA to improve head-to-roof impact protection in rollovers, the agency's rulemaking in reaction to ISTEA addressed only frontal and lateral head impact protection.[127] In 1993, the agency acknowledged the risks, stating that: "since a significant number of serious head injures resulting from impacts with the roof occur in rollovers when it is in contact with the ground, NHTSA believes that it might be appropriate to develop a test procedure which replicates that condition." However, the agency at that point claimed it lacked information sufficient to perform such testing.

In the 1970s, General Motors began to significantly improve head impact performance in some of its vehicles with a technology called "air gap" padding, which involves layers of tiny overlapping semicircles of thin aluminum. Despite the considerable safety benefits of using the air gap technology, by the 1980s GM discontinued its use in most of its vehicles.

In response to these oversights, S. 1072 requires NHTSA to issue a rollover crashworthiness standard by June 30, 2006, for passenger vehicles under 10,000 lbs. In formulating the standard, NHTSA is asked to consider development of a dynamic roof strength standard and to consider seat structure improvements, side impact head protection air bags and roof injury protection measures that could include improved interior roof padding.

Ejection Risks Demand Reduction through a Multi-Pronged Approach

Ejection is the most dangerous risk for people involved in any vehicle crash, and the dynamics of rollovers make occupants particularly susceptible to it. Despite record-high belt use rates, an unnecessary number of belted occupants continue to be partially or even fully ejected from vehicles when they roll over.

Ejection is a serious risk for the unbelted as well. Each year, 7,300 people are killed each and nearly 8,000 are severely injured when partially or fully ejected through vehicle doors, windows and sun or moon roofs. Research by NHTSA at the brink of the '90s highlighted the fact that since issuance of Standard 206 in 1971, the side window has usurped the side door as the chief opening for fatal ejection. In fact, half of all ejections in rollover crashes are currently through closed windows.[128] An estimated 1,300 lives could be saved each year by improving the strength of side and rear windows enough to retain occupants with side window glazing.[129] And many of the 2,500 annual door ejection deaths could be prevented with upgraded locks and retention components that keep doors from flying open during crashes.[130]

NHTSA pursued a research and testing program throughout the 1990s and in its 2000 notice, the agency stated that anti-ejection side window glazing would save as many as 1,300 lives a year. Yet, based on results of a single dummy test, the agency has ceased work on glazing as a priority.

Senate bill S.1072 would require issuance of a new standard to reduce occupant ejection including strengthening door locks, latches and retention components of doors and *consideration* of requirements for advanced side window glazing and side curtain airbags.

Side Impact Head Air Bags Would Prevent Both Ejection and Severe Head and Neck Injuries

When a vehicle rolls over, the vehicle occupants are pulled vertically out of the seat, and are also pulled towards the outside of the vehicle as it spins by centrifugal forces, increasing the risk of partial ejection through the window or contact with the vehicle interior. Pretensioned belts would help, but protection is still needed to prevent the head from being violently jerked to the side.[131]

Data from recent crash tests by the Insurance Institute for Highway Safety (IIHS) indicate that side head air bags can reduce fatality risks of occupants involved in side impact crashes by up to an amazing *one-half.*[132] While the government does not require installation of side head air bags or apply any safety standards to them, there is every reason to believe that side air bags could substantially decrease both head injury and ejection risks for rollover victims as well.

CONCLUSION

The problem of rollover survivability is far from insoluble, if regulators and the industry address the total picture of risk to occupants, both belted and unbelted. An integrated approach that includes measures to prevent roof crush, ejection and belt failure is an absolute necessity. A vehicle designed with a sturdy roof may still not provide adequate occupant protection if the safety belt allows the occupant to move off the seat to contact the interior of the vehicle. Likewise, the safest safety belt system in the world can do little to reduce the risk of injury if the roof is weak and crushes down into a belted occupant's survival space.

Only a systems approach to the design of the vehicle, taking into account the roof strength in a roll, ejection mitigation goals, and the safety belt system in combination can truly prevent or alleviate head and spinal injuries caused by rollover. Title IV of S. 1072 adopts such an approach, by highlighting the risks but allowing NHTSA to write the standards. Dr. Jeffrey Runge, Administrator of NHTSA, predicted last year that the total deaths from motor vehicle crashes could reach **50,000 annually** in 2008. "*This is a Vietnam War every year*," he said. "*That's just not tolerable*."[133]

It is far past time for NHTSA to address the largely unregulated hazards of rollovers, and the high costs of an SUV- and pickup-heavy vehicle fleet. Congress should enact S. 1072, and NHTSA should move eagerly and quickly forward in its mission to save lives.

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APPENDIX A

SUV SALES EXPLOSION INCREASES NUMBER OF ROLLOVERS, WHILE MAJOR ROLLOVER RISKS REMAIN UNADDRESSED

Explosive SUV Sales Propelling Rollover Crisis

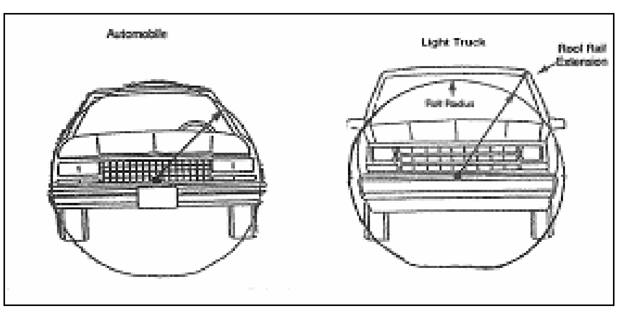
Behind the rising rollover death toll are the recent soaring sales of light trucks, particularly SUVs and pickup trucks. Light truck sales have doubled since 1983 and now are half of all vehicle sales. The market share of sport utilities has risen explosively — by a multiple of ten — since over the past three decades. In 1975, SUVs were less than 2 percent of the overall new vehicle market; in 2003, however, SUV sales alone constituted more than 23 percent of the market.[1] The engine behind this sales phenomenon is over *$9 billion* poured into advertising SUVs by automakers and dealers during the 1990s. The growth in ad spending actually eclipsed the growth rate for SUV sales.[2] Manufacturers have focused on making SUVs appeal to women, who, according to marketing data, influence 80 percent of vehicle purchases.[3]

SUV Rollover Risks High

The high frame and center of gravity and unstable design of SUVs makes rollovers particularly likely, and weak roofs and lack of crash protections make them deadly when they do occur. While 22 percent of passenger car occupant fatalities are attributable to rollover, a whopping 61 percent of SUV occupant fatalities are caused by rollover crashes.[4] NHTSA estimates that 7,000 people are killed or seriously injured when the vehicle they are in rolls over and the roof collapses into the occupant survival space.[5]

Rollovers are also particularly violent in SUVs and pickup trucks. The box-like, windowed passenger area of an SUV (called the “greenhouse”), protrudes into the air and, in a roll, hits the ground with more force due to its shape. Rolling “like a box” creates a more violent rollover crash upon impact with the ground, in comparison with the crash dynamics of passenger cars, which roll more like barrels. Centrifugal forces push passengers’ heads towards the outside of the roll and into contact with the vehicle’s sides and roof just as the vehicle impacts the ground, and can crush the roof inward, collapsing the survival space with deadly consequences.

Figure A-1: Hazardous Box-like Cab Structure of Light Trucks



Crash Dynamics Make Rollovers among the Most Survivable Type of Crash

In spite of the carnage that rollovers currently inflict, the specific crash dynamics of a rollover crash should make them highly survivable. The vehicle's deceleration is usually spread out over a moderately long period of time and through a series of impacts, rather than a single tremendously violent one. Because the force of the roll dissipates over time, decent crash protection could enable survival. And most rollovers are single-vehicle crashes, caused by the vehicle being "tripped" by roadside gravel, sand, curb, or an uneven road surface.

Roof Crush Continues to Be a Severe Risk to People in Rollovers

Roof integrity is the most fundamental element of occupant safety in a rollover crash. If the roof is weak, it will collapse into the cab as the vehicle rolls. Moreover, a weak roof will transmit force onto the windows as it strikes the ground, ensuring that windows break and further compromising the roof strength during subsequent rolls. Weaker roofs also transfer more force onto the doors, increasing the chances of door and door frame deformation. Both of these structural failures mean that a weak roof greatly increases the risk of ejection through a door or window.

Because of light trucks' box-like cabs, heavy weight, and weak roofs, roof crush greatly increases light truck occupant risks in a rollover crash. These heightened risks distinguish SUVs and pickups from passenger cars and in some part may account for the dramatically higher rollover fatality rates in those vehicles.

Despite the essential nature of roof integrity, the current static roof crush resistance standard is long out-of-date and severely inadequate. The standard has only been revised since 1971 to encompass vehicles with a gross vehicle weight rating (GVWR) of 6,000 pounds or less and to vehicles with raised roofs. The standard's weight limit has allowed some manufacturers to increase the weight of vehicles by marginal amounts over 6,000 pounds in order to evade the standard. A 1995 evaluation of the U.S. roof crush resistance standard by the Australian government concluded that it provided almost no enhanced protection of the occupant survival space.[6]

Endnotes

[1] U.S. Environmental Protection Agency. *Light-Duty Automobile Technology and Fuel Economy Trends: 1975 Through 2003.* (EPA 420 R03 006). Washington, DC: General Printing Office, April 2003, at 16.
[2] Bradsher, Keith. *High and Mighty: SUVs — The World's Most Dangerous Vehicles and How They Got That Way,* New York: Public Affairs, Sept. 2002, at 112.
[3] Interview with Martin Goldfarb, "Rollover: The Hidden History" *Frontline,* PBS, June 2002. <http://www.pbs.org/wgbh/pages/frontline/shows/rollover/interviews/goldfarb.html>.
[4] Jeffrey W. Runge, M.D., Administrator, National Highway Traffic Safety Administration, "Meeting the Safety Challenge" at Automotive News World Congress, Dearborn, Michigan, Jan. 14, 2003.
[5] Plungis, Jeff, and Bill Vlasic, "Feds, Big Three gird for roof showdown" *Detroit News,* April 13, 2004.
[6] Plungis, Jeff, and Bill Vlasic, "Safety test ignores real-life conditions" *Detroit News,* April 11, 2004.

APPENDIX B-1

The Sad History of Rollover Prevention – 30 Years, Thousand of Deaths and Injuries, and Still No Safety Performance Standard

Rollover crashes are responsible for a full one-third of all vehicle occupant fatalities, yet meaningful federal action to reduce these crashes has been delayed for more than three decades.

April 1973	The National Highway Traffic Safety Administration (NHTSA) issues an Advanced Notice of Proposed Rulemaking (ANPRM) on a rollover resistance standard "that would specify minimum performance requirements for the resistance of vehicles to rollover in simulations of extreme driving conditions encountered in attempting to avoid accidents." No safety standard has ever been issued.
1986	NHTSA analysis shows that rollover crashes are the most dangerous collision type for passenger vehicles.
Sept. 1986	Rep. Tim Wirth, the Chairman of the House Commerce Committee petitions NHTSA to issue a rollover standard based on Static Stability Factor (SSF) – a geometric measurement concerning the relationship between vehicle height and track width.
Dec.1987	Rep. Tim Wirth petition denied by NHTSA on the basis that SSF does not accurately predict rollover propensity. SSF was later adopted in the year 2000 as the basis for the agency's rollover resistance consumer information program, but not as a minimum safety standard.
Feb./July 1988	The Center for Auto Safety (CAS) and the Safety First Coalition (SFC) petition NHTSA to initiate a defect investigation on the highly rollover-prone Suzuki Samurai.
June1988	Consumers Union petitions NHTSA to protect occupants against "unreasonable risk of rollover."
Sept. 1988	NHTSA grants Consumers Union petition and states that it is already undertaking research into rollover safety and that the petition is consistent with the agency's "steps to address the rollover problem." NHTSA simultaneously denies the CAS and SFC petitions to investigate the Samurai
1988 -1993	NHTSA conducts an investigation and data analysis of more than 100,000 single-vehicle rollover crashes.

Oct. 1991	Congress requests report from NHTSA regarding rollover and roof crush standards (FY'92 DOT Appropriations Act, Pub. L. 102-143, S. Rept. 102-148).
Dec.1991	Congress requires NHTSA rulemaking to prevent unreasonable risk of rollover. An ANPRM or Notice of Proposed Rulemaking (NPRM) was required no later than May 31, 1992 and completion of a rulemaking action on rollover within 26 months of publication of the ANPRM. Yet Congress allowed the rulemaking to be considered completed when NHTSA either published a final rule or announced that the agency would not promulgate a rule.
Jan. 1992	NHTSA publishes an ANPRM proposing multiple options for establishing a reasonable metric baseline for acceptable rollover propensity. The ANPRM states that NHTSA is considering regulatory action to reduce the frequency of rollovers and/or the number and severity of injuries resulting from vehicle rollovers. A Technical Assessment Paper was also published discussing testing activities, results, crash data collection and data analysis (NHTSA-1996-1683-4).
April 1992	NHTSA issues Report to Congress, *Rollover Prevention and Roof Crush*, highlighting the research and its plans to address rollover prevention and survival.
Sept. 1992	NHTSA delivers the agency's planning document, *Planning Document for Rollover Prevention and Injury Mitigation*,[1] at Society of Automotive Engineers Conference, giving an overview of the rollover problem and the action NHTSA was examining to address it, including vehicle measures for rollover resistance; improved roof crush resistance to prevent head and spinal injury, and improved side window glazing and door latches to prevent occupant ejection.
June 1994	Rollover standard rulemaking terminated following a cost-benefit analysis that used out-dated late 1980s data regarding the prevalence of light trucks in the vehicle population and ignored the significant trend of increasing rollover-prone vehicles, namely SUVs, as a percentage of new vehicle sales and an increasing presence on the highway.

June 1994	Secretary of Transportation, Federico Peña, announces NHTSA’s plans to substitute a “comprehensive regulatory and information strategy” for the rollover propensity standard. This strategy included 1) a safety sticker to be placed on all vehicles that includes their rollover likelihood rating (watered down following Industry complaint, it now only mentions a generic likelihood of rollover); 2) the consideration of new standards for side windows and door latches (yet to be promulgated); and 3) examination of an upgraded roof crush standard (yet to be promulgated).
July 1994	NHTSA issues a notice of rulemaking on a vehicle safety consumer information label for rollover stability.
July 1994	Advocates for Highway and Auto Safety (Advocates) and Insurance Institute for Highway Safety (IIHS) petition NHTSA to reconsider decision to terminate rulemaking on rollover standard.
Sept. 1994	Congress requires National Academy of Sciences (NAS) study of vehicle safety consumer information (FY’95 DOT Appropriations Act, Pub. L. 103-331, *see* H. Rept. 103-543, Part 1); NHTSA suspends rulemaking on vehicle rollover safety consumer information labeling until study is completed.
Aug. 1995	Responding to a 1991 ISTEA requirement that NHTSA initiate and complete a rulemaking to address "improved head impact protection from interior components of passenger cars (i.e., roof rails, pillars, and front headers)," the agency issues a final rule amending FMVSS 201 to require passenger cars and light trucks with a GVWR of 10,000 pounds or less to provide greater protection when an occupant's head hits upper interior components (such as A-pillars and side rails) during a crash. A rulemaking intended to address roof crush is thereby transformed into a rule on interior padding.
March 1996	NAS issues study of vehicle safety information, *Shopping for Safety*[2], on NHTSA’s proposed consumer information program, stating that consumers need more information then they are currently provided and that a safety label, like the one currently used for displaying fuel economy, should be displayed on all new passenger vehicles sold at U.S. dealerships listing standardized safety ratings.
May 1996	NHTSA issues *Status Report for Rollover Prevention and Injury Mitigation*, with a description of NHTSA’s planned development of a dynamic rollover propensity test.
June 1996	NHTSA re-opens 1994 rulemaking docket on a rollover consumer warning label.

June 1996	NHTSA denies Advocates/IIHS July 1994 petition for reconsideration of decision to terminate rulemaking on rollover preventionstandard, stating that a standard based on static vehicle measurements would eliminate a "very popular vehicle type" – the compact SUV and was not justified on cost-benefit grounds.
Aug. 1996	Consumers Union petitions NHTSA to develop a standard that would produce meaningful, comparative data on the emergency-handling characteristics of various SUVs and to provide test results to the public as consumer information.
May 1997	NHTSA grants CU petition, stating: "NHTSA will initially focus on exploring whether it can develop a practicable, repeatable and appropriate dynamic emergency handling test that assesses, among other issues, a vehicle's propensity for involvement in an on-road, untripped rollover crash."
April 1998	NHTSA issues an NPRM on a SUV rollover warning label for the vehicle visor.
Mar. 1999	NHTSA issues final rule on revised SUV rollover warning label, requiring a rollover warning sticker on the vehicle's visor or window that says "Warning: Higher Rollover Risk" and instructions to avoid abrupt maneuvers and excessive speed, and to buckle up, are written beneath the heading.
June 2000	NHTSA proposes rollover consumer information based on static stability factor (SSF) measurements as part of the agency's New Car Assessment Program (NCAP) that provides comparative vehicle performance information on the agency's Web site, but declines to require that the information be placed on the window sticker at the point-of-sale.
Oct. 23, 2000	Congress funds NAS study of NHTSA proposed rollover information rating based on SSF.
Nov. 2000	Following the Ford Explorer/ Firestone tire tragedy, Congress requires dynamic testing of vehicle rollover be added to NHTSA's consumer information rating program with testing to begin by November, 2002 (TREAD Act, Sec. 12, Pub.L. 106-414).
Jan. 2001	NHTSA begins publishing rollover ratings based on a vehicle's static stability factor (SSF) on the agency's Website.
July 2001	NHTSA issues request for comments on developing dynamic test as basis for rollover rating consumer information program beginning in 2003.

Sept. 2001	According to a Louis Harris poll commissioned by Advocates for Highway and Auto Safety, 85 percent of Americans support a federal rollover prevention minimum standard.
Feb. 2002	NAS study, *Rating System for Rollover Resistance, An Assessment*, issued. The report recommends that NHTSA expand the scope of its program, consider metrics other than stars, and develop an overall measure of vehicle safety to be integrated into the vehicle label. The NAS also points that NHTSA should evaluate the appropriateness of a rollover rating program in the absence of a minimum standard (the other consumer information ratings, for frontal and side impact crashes, reward performance above a minimum compliance standard).
Oct. 2002	NHTSA issues NPRM on dynamic test procedure for rollover consumer information.
Feb. 26, 2003	Senate Commerce Committee holds a well-publicized hearing on SUV safety where Senators, auto industry representatives, the administrator of NHTSA and spokespeople from consumer safety groups speak about the rollover prevention and survivability.
April 2003	NHTSA publishes *Characteristics of Fatal Rollover Crashes*[3] and reports the following: - Rollovers are more likely to result in fatality than other crashes are; - Rollovers constitute about one-fifth of all fatal crashes; - SUVs have the highest rollover fatality rate at 11.06 per 100,000 registered SUVs, followed by pickups at 7.52, vans at 4.09 and cars at 3.48 (for 1999).
June 2003	NHTSA issues *Initiatives to Address the Mitigation of Vehicle Rollover*[4] – reporting that rollover mitigation is one of its four major priority areas, but proposing few concrete actions or deadlines. The other three priority areas include vehicle compatibility, safety belt use and impaired.
July 2003	NHTSA issues *Motor Vehicle Traffic Crash Injury and Fatality Estimates: 2002 Annual Report*[5], finding that rollover crashes accounted for 82 percent of the total fatality increase between 2001 and 2002. The report also reveals that in 2002, 10,666 occupants were killed in rollovers – one-third of all occupant deaths.
Oct. 2003	In accordance with the TREAD mandate, NHTSA adopts a "fishhook" maneuver as the dynamic test procedure to be combined with SSF in rollover consumer information ratings and to be used beginning with its 2004 model year tests. .

Feb. 4, 2004 NHTSA issues first round of rollover ratings for 14 vehicle models and their corporate twins, based on a new dynamic test/SSF measurement. While the dynamic test provides an indication of on-road performance, the absence of a standard, or performance "floor" means that every vehicle starts with at least one star, and inflates the performance results on the tests (*i.e.*, with a two-star "floor," vehicles now earning three stars would receive substantially lower ratings).

Feb. 12, 2004 Senate passes S.1072, the Safe, Accountable, Flexible, and Efficient Transportation Equity Act of 2003 (SAFETEA 2003), which includes safety provisions concerning rollover that would:

- Mandate a rollover prevention standard that would assure the improvement of the basic design characteristics of vehicles under 10,000 lbs to increase their resistance to rollover (NPRM 6-30-04, final rule not later than 18 months following NPRM);
- Require the consideration of additional technologies that would increase handling and reduce the likelihood of instability(NPRM 6-30-04, final rule not later than 18 months following NPRM); and
- Assign NHTSA to study Electronic Stability Control systems and report to Congress on their findings (due 12-31-05)

Endnotes

[1] Planning Document for Rollover Prevention and Injury Mitigation. Docket 91-68. No. 1. Office of Vehicle Safety Standards, Sept., 13 pp. NHTSA. 1993

[2] *Shopping for Safety: Providing consumer automotive safety information*, Transportation Research Board, National Research Council, National Academy Press, 1996.

[3] NCSA, *Characteristics of Rollover Crashes*, DOT HS 809 438, (Apr. 2002), at 14 and 20; *See also* "Registration Data for 1975-2001

[4]National Highway Traffic Safety Administration; *Initiatives to Address the Mitigation of Vehicle Rollover*., 2003. 50 IAMV NHTSA

[5] National Center for Statistics and Analysis, National Highway Traffic Safety Administration. *2002 Annual assessment of motor vehicle crashes. Motor vehicle traffic crash fatality and injury estimates for 2002*. Washington, DC: NCSA, 2003

APPENDIX B-2

1971 Roof Strength Standard – 33-Year Old Standard Does Not Provide Basic Crashworthiness Protections for Occupants in Vehicles that Rollover

The auto industry and government have known about the deadly consequences of vehicle roof crush since 1960s, yet have never upgraded the 1971 standard nor extended it to vehicles weighing more than 6,000 lbs.

July 13, 1965	Both General Motors (GM) and Ford highlight the importance of roof strength in rollovers in testimony before Congress.
Apr. 13, 1966	GM Engineering Staff memo describes the company's plans to develop a dynamic roof strength drop test from 5 ½ feet.
Aug. 1, 1966	Ford test report describes dynamic roof crush "roof drop test."
Sept. 9, 1966	President signs National Traffic and Motor Vehicle Safety Act.
Oct. 11, 1967	Federal Highway Administration (FHA) of the National Traffic Safety Bureau (NTSB) issues an Advanced Notice of Proposed Rulemaking (ANPRM) on 47 issues, including roof intrusion, seeking public comment.
Jan. 6, 1971	The National Highway Traffic Safety Administration (NHTSA, formerly NTSB), issues a Notice of Proposed Rulemaking on roof intrusion protection for passenger cars that would statically test both front corners of the roof on passenger vehicles.
Apr. 1971	General Motors Corporation (GM) and the Automobile Manufacturers Association (which later became the Alliance of Automobile Manufacturers) argued in comments to the docket that testing both sides of the roof was unnecessary. It was later revealed in litigation many years later that GM had used NHTSA's two-corner test on six of its production model vehicles and that only one vehicle tested had passed. GM nevertheless argued to NHTSA that only one side should be tested because the roof was "symmetrical," in addition to pushing for other changes to weaken the test. Moreover, GM withheld its testing results from the agency.
Dec. 8, 1971	NHTSA issues final rule establishing a roof crush standard for passenger cars to take effect in 1973. This standard, which today is virtually the same as in 1973, measure the result of pressure to only one side of a vehicle's roof.

Mar. 22, 1973	The Center for Auto Safety petitions NHTSA to apply federal motor vehicle safety standards, including the roof crush standard, to light trucks and multipurpose passenger vehicles with gross vehicle weight rating (GVWR) of 10,000 pounds or less.
Sept 1, 1973	Roof Crush Resistance standard, FMVSS No. 216, takes effect for passenger cars.
1974	NHTSA contracts with Minicars for development of a research safety vehicle that protects occupants in serious rollover crashes at 50 mph.
April 30, 1976	Engineer killed during accidental rollover at GM proving grounds during a tire evaluation test. GM institutes a new policy requiring roll cages on all test vehicles and all test drivers and test occupants to wear helmets.
Apr. 17, 1991	NHTSA issues a final rule, effective Sept. 1, 1993, extending the application of FMVSS 216, the existing car roof crush resistance standard to light trucks, vans, buses, and multipurpose passenger vehicles (MPVs) with GVWR of 6,000 lbs or less, specifically declining to extend the standard to light trucks, vans, buses and MPVs with a GVWR of up to 10,000 pounds.
Dec. 18, 1991	Intermodal Surface Transportation Efficiency Act (ISTEA) requires application of passenger car safety standards to light trucks, vans, buses, and MPVs with GVWR of 6,000 lbs or less. ISTEA also requires issuance of a standard to improve head impact protection from interior components (roof rails, pillars, and front headers) of passenger cars. ISTEA additionally directs NHTSA to commence a rulemaking proceeding on a standard to prevent rollover crashes.
Jan. 3, 1992	NHTSA issues an advanced notice of proposed rulemaking (ANPRM) to establish a rollover prevention standard, as required by ISTEA.
Sept 23, 1992	NHTSA releases *Planning Document for Rollover Prevention and Injury Mitigation* listing alternative actions agency could take to address rollover problem, including research into improved roof crush resistance to prevent head and spinal injury.
Jan. 22, 1993	NHTSA delays by one year, until Sept. 1, 1994, effective date for application of FMVSS 216, the roof crush standard to light trucks, vans, buses, and multipurpose passenger vehicles with gross vehicle weight rating of 6,000 pounds or less.
June 23, 1994	NHTSA terminates rulemaking on rollover prevention and stability standard. In the notice of termination, the agency promises that it will instead address factors involved in preventing rollover casualties, including roof strength requirements.

May 6, 1996	R. Ben Hogan, Smith and Alspaugh, PC, a law firm, petition NHTSA for rulemaking, and request that the agency require “roll cages” as standard equipment on passenger cars.
Jan. 8, 1997	NHTSA grants petition requesting rulemaking to require “roll cages.”
Apr. 27, 1999	FMVSS 216, the roof crush standard procedure clarified for placement of the test device to accommodate certain vehicles that have raised and/or highly sloped roofs. This change in the standard did not address or upgrade underlying roof crush testing and strength requirements.
Sept, 2000	In wake of the exposé of Firestone tire/Ford Explorer rollover fatalities, NHTSA Administrator states that agency needs to improve roof crush safety standard for rollover protection in testimony before Congress.
Oct. 22, 2001	NHTSA publishes notice and request for comments on roof crush resistance, describing agency roof crush research and testing as a part of its rollover protection program over the past 30 years.
2002	Herbst, B., Forrest, S., Meyer, S., Hock, D. publish their “Alternative Roof Crush Resistance Testing with Production and Reinforced Roof Structures,”[1] that discusses the feasibility of a dynamic roof crush test, stating that “[t]he automotive industry and researchers have used drop testing for years to evaluate roof strength. In the late 1960s’s, SAE developed a standardized procedure to perform full vehicle inverted drop testing. Many domestic and import auto manufacturers have utilized the inverted drop test technique as far back as the 1960s and 1970s to evaluate roof strength.
April 2002	NHTSA publishes its report *Characteristics of Fatal Rollover Crashes*[2] and notes that rollover crashes are more likely to be fatal than other crashes.
Sept. 17, 2002	NHTSA Administrator Dr. Jeffrey Runge states that roof crush intrusion potentially contributes to serious or fatal injury in 26 percent of rollover crashes.[3]
Feb. 26, 2003	Senate Commerce Committee holds a well-publicized hearing on SUV safety where Senators, auto industry representatives, the administrator of NHTSA and spokespeople from consumer safety groups speak about the problems of roof crush in SUV rollovers.
March 3, 2003	*Detroit News* series “Deadly Driving” highlights the failure of NHTSA to upgrade its roof strength standard and cites NHTSA data indicating that 1,400 deaths and 2,300 serious injuries could be prevented if the standard were more rigorous.

July 15, 2003	National Transportation Safety Board (NTSB) concludes roof crush contributed to severity of driver injuries and diminished passenger survivable space in Henrietta, Texas crash of 15-passenger van that killed four occupants and seriously injured eight others.
July 2003	NHTSA issues *Motor Vehicle Traffic Crash Injury and Fatality Estimates: 2002 Annual Report*, finding that rollover crashes accounted for 82 percent of the total fatality increase between 2001 and 2002. The report also reveals that in 2002, 10,666 occupants were killed in rollovers – one-third of all occupant deaths.
July, 2003	NHTSA estimates that 1,339 serious or fatal injuries caused by roof crush intrusion are suffered by belted occupants each year. NHTSA lists a proposed rule to upgrade roof crush resistance as a possible 2004 action, and final rule as a possible 2005 action, in *Vehicle Safety Rulemaking Priorities and Supporting Research 2003-2006*, with little description of a rule's possible contents No proposal for rulemaking or an upgraded standard has yet been issued.
Nov. 25, 2003	S.1978 reported out of Senate Commerce, Science and Transportation Committee containing a mandate for NHTSA to issue a dynamic roof crush standard and upgrade of rollover crashworthiness in vehicles up to 10,000 pounds.
2003 - Jan. 2004	Safety researchers at Xprts, Inc., conduct roof crush dynamic tests using the Jordan Rollover System (JRS) on Chevrolet Blazers, Chevrolet Suburbans and Ford Explorers. During the JRS tests, the roadway surface moves forward along a track, contacting the roof of the vehicle as it rotates on the spit. The test surface impacts both *sides of the roof a single time*, imitating the first roll of a vehicle in a rollover crash. The results show that while the current static test measures only the weakness of the roof, dynamic tests measure occupant injury, safety belt performance, window glazing, side impact air bags, seatback strength, and door locks and latches, as well as roof strength.
Feb. 12, 2003	Senate passes S.1072, the Highway Funding Bill, which includes safety provisions from S.1978 that would: - Require NHTSA to issue a rollover crashworthiness standard by June 30, 2006, for passenger vehicles under 10,000 lbs that will consider the prescription of a dynamic roof strength standard that realistically duplicates actual forces; - Require NHTSA consideration of improved seat structure and safety belt design (including seat belt pretensioners), side impact head protection airbags, and roof injury protection measures.

Endnotes

[1] Herbst, B., Forrest, S., Meyer, S., Hock, D., “Alternative Roof Crush Resistance Testing with Production and Reinforced Roof Structures”, SAE 2002-01-2076
[2] NCSA, *Characteristics of Rollover Crashes*, DOT HS 809 438, (Apr. 2002), at 14 and 20; *See also* "Registration Data for 1975-2001
[3] Runge, Jeffrey. Speech to the 3rd Motor Vehicle Safety Symposium, United Nations University, Tokyo, Japan, September 17, 2002. < http://www.nhtsa.dot.gov/nhtsa/announce/speeches/020917Runge/UNU%20speech.doc>

APPENDIX B-3

Government Stalls on Reducing Ejections – No Standard for Windows that Reduce Ejection Door Lock Retention Standard Remains Unchanged for over 30 Years

Each year 7,300 people are killed each and nearly 8,000 are severely injured when partially or fully ejected through vehicle doors, windows and moon roofs. An estimated 1,300 lives could be saved each year by improving the strength of side and rear windows enough to retain occupants. And many of the 2,500 annual door ejection deaths could be prevented with upgraded locks and retention components that keep doors from flying open during crashes.

Jan. 1, 1968	Standard 206 - Door Locks and Door Retention Components – takes effect and is aimed at "minimizing, the likelihood of occupants being thrown from the vehicle as a result of impact."
Jan. 26, 1981	NHTSA seeks public comment on the safety advantages of advanced window glazing (the addition of materials, such as plastic, to side and rear windows to increase elasticity of windows and decrease complete breakage of window upon impact).
Aug 1988	NHTSA issues two advanced notices of proposed rulemakings (ANPRMs) on side impact protection, seeking comment on increasing resistance to occupant ejection through side widows – one for both cars and another for light trucks (SUVs, pickups and vans). NHTSA conducts testing on improved glazing materials between 1988 and 1995.
Jan. 3 1992	NHTSA publishes an ANPRM on rollover protection which included discussion of preventing ejection through glazing during rollovers.
June 1994	NHTSA cancels its proposed rule to establish a vehicle stability standard to reduce rollover crashes and promises to pursue multiple strategies to reduce occupant injury and its severity when vehicles do suffer rollovers. One of the initiatives is anti-ejection countermeasures including improved door locks and latches and window glazing.
July 1995	NHTSA holds public meeting on improvements in door latch and lock standards and asks for public comments on the issue.
Sept. 1995	NHTSA publishes final rule in 1995 extending the requirements of the 1968 door lock standard to the back doors of passenger cars and multi-purpose vehicles (hatchbacks, station wagons, SUVs, and passenger vans) after finding that weak locks are often the cause of rear doors popping open in rear crashes and killing children.

Nov. 1995	NHTSA issues "Ejection Mitigation Using Advanced Glazings: A Status Report"[1] report on positive safety effects of anti-ejection glazing.
Feb. 1, 1996	NHTSA holds public meeting on glazing and occupant ejection and to discuss the findings of the ejection mitigation status report released the previous November.
Sept. 1999	NHTSA proposes that no doors open in frontal crash testing, but at least one door should be able to be opened following the test.
Nov. 1999	NHTSA deletes proposed door retention/opening requirements.
Nov. 1999	NHTSA issues "Ejection Mitigation Using Advanced Glazing, Status Report II."[2] Findings in both the 1995 and 1999 status reports show that advanced glazing is capable of preventing approximately 1,300 fatalities per year and that feasible and practical prototypes exist.
Nov. 2000	NHTSA issues an ANPRM on safety benefits of anti-ejection glazing.
Nov. 2001	NHTSA issues a report "Ejection Mitigation Using Advanced Glazing" to Congress, reversing its previous decision that the safety benefits of advanced glazing are very high.
March 3-6, 2003	*Detroit News* series "Deadly Driving" highlights window strength and door locks/hinges as primary ways NHTSA could enhance safety. The report cites government statistics to note that between 537 and 1,305 fatalities could be prevented annually from improved side windows and that updated door latch standards could prevent hundreds of the 2,500 door-related ejection deaths each year.[3]
April 2002	NHTSA publishes its report "Characteristics of Fatal Rollover Crashes" and notes that 62 percent of occupants killed in vehicle rollovers were ejected during the crash and that only 23 percent of survivors of rollovers were ejected.
June 18, 2002	NHTSA withdraws its side glazing rulemaking notices and closes the two dockets established in 1988. The chief decision to terminate was based on the finding of an increased risk of neck injury, yet the test used to measure neck injury was problematic and non-repeatable, and onely one of a number of vehicles tested had these negative results.
Feb. 2003	NHTSA proposes development of global technical regulation governing the design and performance of door locks, latches, and retention components pursuant to the 1998 U.N. Economic Commission for Europe Global Agreement.

Feb. 26, 2003	Senate Commerce Committee holds a well publicized hearing on SUV safety where Senators, auto industry representatives, the administrator of NHTSA and spokespeople from consumer safety groups speak about the problems of ejection in SUV rollovers.
Dec. 2003	In NHTSA's 2003-2007 Priority plan, the agency promises to propose a rule upgrading door lock and latch design and performance by April 2004 and a final rule by 2005.
Feb. 12, 2004	Senate passes S.1072, the Safe, Accountable, Flexible, and Efficient Transportation Equity Act of 2003 (SAFETEA 2003), which includes safety provisions concerning ejection that would: - Mandate a standard be set to reduce occupant ejection including the consideration of advanced side glazing, side curtain airbags and side impact airbags; and (Notice of Proposed Rulemaking (NPRM) 6-30-2006, Final Rule not later than 18 months following NPRM); - Assure the creation of a standard that would require manufacturers to strengthen door locks, latches and retention components of doors to prevent occupant ejection (NPRM 6-30-2006, Final Rule not later than 18 months following NPRM).

Endnotes

[1] NHTSA Advanced Glazing Research Team; "Ejection Mitigation Using Advanced Glazing: A Status Report;" November 1995; NHTSA Docket 95-41 GR.
[2]NHTSA Advanced Glazing Research Team; "Ejection Mitigation Using Advanced Glazing, Status Report II, August 1999;" August 1999; NHTSA Docket 95-41 GR
[3] Zagaroli, Lisa; "Agency quietly rejects stronger glass standard," *The Detroit News* March 3, 2003.

APPENDIX C

NCAP-TESTED 2003 MODEL YEAR VEHICLES WITH INTEGRATED SAFETY BELTS

Key: S = Standard
A = Available

Make	Model	Integrated Seat Belt
Acura	MDX	S
BMW	3 Series	S
BMW	3 Series/M3 2-DR	S
BMW	3 Series/M3 Convertible	S
BMW	3 Series Sports Wagon	S
BMW	5 Series	S
BMW	7 Series	S
BMW	Alpina Roadster	S
BMW	X5	S
Buick	LeSabre	S
Buick	Park Avenue	S
Cadillac	CTS	S
Cadillac	De Ville	S
Cadillac	Escalade	S
Cadillac	Escalade EXT	S
Cadillac	ESV	S
Cadillac	Seville	S
Chevrolet	Avalanche	S
Chevrolet	Silverado	S
Chevrolet	Silverado Crew Cab	S
Chevrolet	Silverado ExCab	S
Chevrolet	SSR	S
Chevrolet	Suburban	S
Chevrolet	Tahoe	S
Chevrolet	Trailblazer	S
Chevrolet	Trailblazer EXT	S
Chrysler	Sebring Convertible	S
Ferrari	456 M	S
Ford	Expedition	S
Ford	Explorer	S
Ford	Explorer Sport Trac	S
Ford	F-150 ExCab	A
Ford	F-150 King Ranch Crew	S
GMC	Envoy	S
GMC	Envoy XL	S
GMC	Sierra	S
GMC	Sierra Crew Cab	S
GMC	Sierra ExCab	S
GMC	Yukon	S
GMC	Yukon XL	S
GMC	Yukon Denali	S
GMC	Yukon Denali XL	S
Honda	Insight	S
Honda	Odyssey	S
Honda	Pilot	S
Hyundai	Elantra	S
Isuzu	Ascender	S
Lexus	GX470	S
Lexus	LX470	S
Lexus	RX300	S
Lincoln	Aviator	S
Lincoln	Navigator	S
Mercedes Benz	CL-Class	S
Mercedes Benz	SL-Class Convertible	S
MINI	Cooper/ Cooper S	S
Oldsmobile	Aurora	S
Oldsmobile	Bravada	S
Pontiac	Bonneville	S
Saturn	VUE	S
Toyota	4-Runner	S
Toyota	Highlander	S
Toyota	Land Cruiser	S
Toyota	Sequoia	S
Volvo	V40	S
Volvo	V70	S
Volvo	XC70	S

Source: National Highway Traffic Safety Administration

APPENDIX D

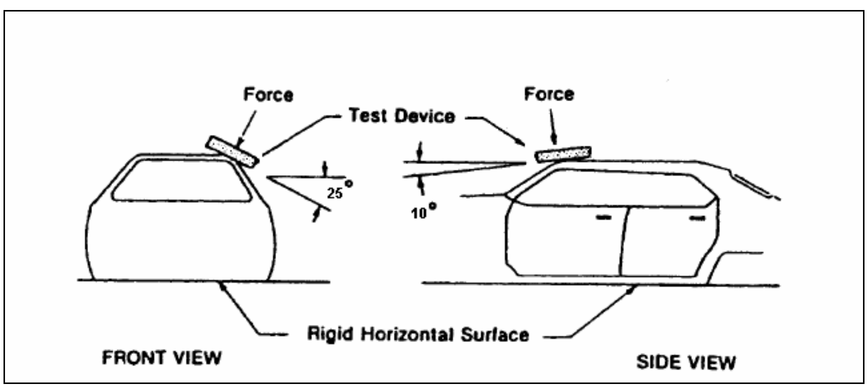
Industry Concealment of Tests Undermined Development of Meaningful Rollover Crash Roof Crush Resistance Standard in 1971

Newly released documents, now available on Public Citizen's Web site, establish how General Motors withheld information from federal safety regulators 30 years ago, just as the government was working to establish the roof crush resistance safety standard that is still on the books. The company hid internal testing results showing vehicle design failures, arguing instead for a roof crush resistance standard that it knew did not require major improvements in the roof integrity of its 1970s vehicles. This standard — still on the books after 33 years — allows vehicles to be produced and sold to consumers with roofs that crush into the passenger survival space during a rollover, severely injuring or killing people inside the vehicle.

Auto Industry Conceals Truth, as Now Revealed by Internal Company Documents

On January 6, 1971, the National Highway Safety Bureau (NHSB, which later became the National Highway Traffic Safety Administration, or NHTSA) proposed a safety standard to "reduce deaths and injuries due to the intrusion of the roof into the passenger compartment in rollover" crashes. (*See* "Roof Intrusion Protection for Passenger Cars, Proposed Rule Making," *Federal Register* 36, Jan 6, 1971, at 166.)

The agency's initial proposal was a test of both front corners of a passenger vehicle roof. Both corners would be tested by lowering a 12-inch square platen, angled forward 10 degrees horizontally and 25 degrees laterally, successively onto each front corner, increasing the force until it equaled one-and-one-half the weight of the vehicle, or 5,000 lbs., whichever was less. To pass the test, the roof could not have more than 5 inches of intrusion into the passenger compartment.



Graphic for illustration purposes only, not from litigation papers.

On April 5, 1971, General Motors and the Automobile Manufacturers Association (AMA, now re-named the Alliance of Automobile Manufacturers) submitted comments arguing for important and weakening changes to the proposed test procedures. (*See* Comments of Automobile Manufacturers Association. "Roof Intrusion Protection for Passenger Cars, Proposed Rule Making," Docket No. 2-6; Notice 4, April 5, 1971, *and* Comments of General Motors Corporation. "Roof Intrusion Protection for Passenger Cars, Proposed Rule Making," Docket No. 2-6; Notice 4, April 5, 1971.)

In its comments, the auto industry sought to weaken the standard in several key ways. The first was to change the orientation and dramatically increase the size of the platen. GM argued, on page 3, that NHTSA's proposal for a 12-inch by 12-inch platen was too small of an area of the roof to be appropriate for the test. GM urged NHTSA to substantially increase the size of the testing platen to at least 30 inches by 72 inches, to provide "a more realistic loading condition for evaluating roof strength." On the eighth page of its comments, the AMA also recommended the use of a large platen. Moreover, both GM and the AMA suggested — on the 6^{th} and 8^{th} pages, respectively — that the forward horizontal orientation of the platen be reduced from ten degrees to five.

Second, the industry urged NHTSA to abandon testing of both sides of the roof consecutively and to limit the test to only one side of the roof. The AMA argued that testing both sides of the vehicle roof was unnecessary. On pages 10 and 11 of its comments, the AMA asserted that "in most cases roof structure damage is distributed to only one side of the roof in an actual rollover situation." Moreover, the AMA continued, "since the upper car structure is symmetrical," the AMA wrote, "it makes no difference which side of the roof is selected for testing." On page 11 of its comments, the AMA further asserted that:

> [I]t is very questionable whether repeatable or reliable results can be obtained by testing both sides of this same roof structure system. This follows from the fact that consistent material deformation in the vicinity of the second test cannot be assured after an initial destructive test on the first side.

GM endorsed and incorporated by reference the AMA comments. Its specific proposed revisions to the agency's language of the standard suggested that NHTSA omit the testing of both sides from its test procedures. On page 10 of GM's comments, "repeat the test on the other front corner of the roof of the vehicle," has been crossed out.

The third critical item suggested by industry to weaken the standard was that, during a test, all vehicle glass should be intact, and all windows in a closed position. General Motors, on page five of its comments, inserted language stating that "[a]ll fixed glass shall be installed and moveable glass shall be in its closed position." The AMA recommended the same language on the 8^{th} page of its comments. The trade group argued that "the status of the glass is defined to assure adequate control of potential test variables." Of course, test parameter "definition" could be equally assured by a standard that omitted glass in the windows for the purposes of the test.

NHTSA Issues Critically Flawed Roof Crush Standard

Internal documents demonstrate that GM was well aware that its vehicles had severe roof strength problems. Yet the company withheld pertinent information from NHTSA in its comments. In a General Motors meeting on May 13, 1966, GM Director of Automotive Safety Engineering confessed that "We are presently in trouble with the "A" or Number 1 (front roof-supporting) pillar. (*See* Report No. PG-21773, Lundstrom, L. C. Inter-Organization Letter, 1969 GM Safety Design Goals – Body Design – No. 1 Pillar. Detroit, General Motors, May 16, 1966, at 7.)

After publication of NHTSA's proposed roof crush standard, GM conducted roof crush resistance tests on six of its own vehicle models. The tests were done in accordance with NHTSA's proposal. Five of the six GM vehicles failed the test. GM's test report, dated March 5, 1971, concluded that "all the bodies tested failed to meet the requirements of the proposed roof intrusion requirements (Docket 2-6 Notice 4) except the X-27 body that passed. (*See* Timinsky, P.J. *Product Test Report* No. 111037. Detroit, General Motors, Mar. 5, 1971.)

In its comments to NHTSA, GM failed to mention these testing results. GM's comments instead undermined the effectiveness of the roof crush test and standard.

All three of the key industry suggestions highlighted in the previous section play a significant role in weakening the test. To address the first, increasing the size of the platen reduces the amount of force per square inch applied to a test vehicle's roof. And reducing the angle of the platen from ten to five degrees reduces the force applied to the front corner roof pillars. Yet rollover crashes combine both lateral and downward forces in a manner more similar to NHTSA's initial proposal, meaning that industry's suggested changes moved the test farther away from the crash impacts in real-world rollover crashes.

GM was likely aware of these implications — in 1966, it had internally recommended a roof crush drop test in which the impact surface was at a far sharper angle, relative to the front horizontal orientation of the vehicle roof — the opposite of its recommendations to NHTSA in 1971. (*See* Lundstrom, L. C. Inter-Organization Letter. Subject: Design Goals for Safety. Detroit, General Motors, April 19, 1966, at 5.)

Secondly, while both GM and the AMA argued against testing both sides of the roof due to the roof's alleged symmetry, the dynamics of real-world rollover crashes are far from symmetrical in their impacts on the roof. A consecutive test for both corners is critical because the initial impact on the roof in a rollover crash substantially degrades the integrity of the roof structure, meaning that the "second impact" is far more devastating than the first, and usually at a more lateral angle than the initial impact.

In fact, real-world rollover injuries show that people seated beneath the corner of the "second impact" on the roof are the ones most often killed or severely injured. While the first impact can be glancing, the second impact occurs after the initial integrity of the roof has been severally degraded by the crash. Therefore, the strength of the roof's second corner – in a consecutive test scenario – is fundamental to preventing deadly roof collapse.

Third, the industry's argument that defining test parameters should lead NHTSA to allow windshields and windows to remain intact for the test has led to a dangerous over-reliance by manufacturers on the strength of window bonding to pass the test. Yet in a real-world rollover crash, the glass breaks after the initial (first corner) impact. *When the windshield shatters at first impact, roof strength can decrease by as much as one-third.* Testing only one side of a vehicle's roof with the glass intact allows the measure of roof integrity to be enhanced by the initial influence of the glass, a protection that real-world rollover victims are stripped of in an actual crash.

At least as early as 1966, GM also knew of the influence that windows have in improving roof strength ratings. "Retention of the windshield is advantageous in the event of a roll-over due to the added strength," noted C. W. Gadd of GM Research Laboratories, to colleagues at an internal meeting in 1966. (Report No. PG-21773; Lundstrom, L. C. Inter-Organization Letter. Subject: 1969 GM Safety Design Goals – Body Design – No. 1 Pillar. Detroit, General Motors, May 16, 1966, at 9.)

Without the benefit of the industry's crash test information showing a massive failure to meet the proposed test, NHTSA published its roof crush resistance standard, Motor Vehicle Safety Standard 216, in December of 1971. The final standard reflects, almost without change, the modifications to the rule that had been suggested by GM and the AMA. (*See* "Part 571 — Motor Vehicle Safety Standards," *Federal Register* 36, Dec. 8, 1971, at 23299-23300.)

The standard, which remains in effect today, requires the use of a flat platen 30 inches by 72 inches in dimensions, positioned at a forward angle of five degrees below the horizontal — exactly as GM requested. The rule requires that all vehicle glass be installed and all glass windows closed. In addition, it requires that only one side of the vehicle roof be tested. The death toll from roof crush alone now totals some 7,000 people a year— meaning that tens of thousands, if not hundreds of thousands, of people have unnecessarily died over the past three decades from this flimsy standard, and the lack of protection that it offers occupants in an actual rollover crash.

AUTOMOTIVE SAFETY RESEARCH OFFICE

SAFETY ENGINEERING EVALUATION

Intra Company

ENGINEERING STAFF

July 8, 1968

Mr. H. G. Brilmyer

From: Mr. J. R. Weaver

Subject: Roof Strength

CONCLUSIONS

1. Based on a statistical analysis of accident data, the amount of roof damage has little effect upon the severity of injuries sustained by unrestrained occupants.

2. Roof intrusion may have a more pronounced effect on occupant injuries with increased usage of upper torso restraints.

3. Roof intrusion to 29.4 inches above the "H" point will not interfere with the "depressed head" space of 99% of vehicle occupants.

4. Maximum roof strength in company passenger cars is presently in the 2000 lb (convertible) to 6500 lb (4-door sedan) range.

RECOMMENDATIONS

1. The static roof crush test should be adopted as the standard method of testing roof strength.

2. When subjected to a roof crush test, all passenger vehicles should withstand a load equal to twice the curb weight of the vehicle with maximum roof intrusion to within 29.4 inches vertically above the "H" point.

DISCUSSION

A. Rollover Accident Data

A review of traffic accident data was undertaken to determine the number of accidents involving roof damage and the relationship, if any, between roof collapse and occupant injuries. In an ACIR report of rural personal injury accidents, the roof was the principal area of impact 24% of the time (Reference 1). Unfortunately, the percentage cannot be extrapolated to the national level but it does indicate that the incidence of roof impact is significant.

EAA-0279

In a study of 15 recent injury producing rollover accidents in Washtenaw County (Reference 2), one of the 26 occupants sustained injuries due to roof collapse. For all other occupants, "injury could not be related to the degree of roof collapse".

In a report by Huelke and Gikas (Reference 3) of 139 fatal accidents, 9 occupants died from roof contact. Four of these deaths involved roof-into-tree impact resulting in total roof collapse. A fifth death involved a bizarre roof-to-roof impact between an airborn, inverted car and an oncoming car. The remaining four deaths were from off road, rollover without collision accidents with roof collapse ranging from - in. to total collapse. In all but two of these nine cases, the roof was collapsed to the belt line or below.

An extensive statistical study was performed on the company ACIR* file of 1601 rollover without collision accidents. This study is discussed at length in the Appendix. The results of the study indicate:

1. The amount of roof damage has little effect upon the severity of occupant injuries.

2. Belted occupants sustain slightly more severe injuries than unbelted, non-ejected occupants.

The preceding is a summary of available rollover accident statistics from which only some very basic conclusions can be drawn:

1. A significant number of accidents result in roof damage.

2. People are injured by roof collapse. The total number of nationwide deaths and injuries cannot be estimated but it is a significant number.

3. In rollover accidents, roof structure impacts not only the ground, but fixed objects (trees, guard rails, etc.).

B. Upper Torso Restraints

Upper torso restraints are mandatory on passenger vehicles in 1968. At present, their usage is rare. It is expected that in time they will become more widely used and more effective. For protection from forward and side impact, an upper torso restraint system should hold the wearer in an upright or slightly jackknifed position. The Ford "inverted Y" harness, race car "H" harnesses and "X" harnesses are examples of very effective upper torso restraints.

It is obvious that occupants that are restrained in upright positions are more susceptible to injury from a collapsing roof than unrestrained occupants who are free to tumble about the interior of the vehicle. It seems unjust to penalize people wearing effective restraint systems by exposing them to more severe rollover injuries than they might expect with no restraints.

*Automotive Crash Injury Research of Cornell University

EAA-0280

C. Head Clearance

The occupant population head height and selected interior roof heights are shown in Figure 1. The top of head curve was obtained from Reference 4 and the vehicle dimensions from Reference 5. The measured vehicle dimensions were adjusted to vertical dimensions (the measurement is taken 8° from vertical). The depressed head location is based on the assumption that occupants can comfortably lower their head height 2 inches without moving their shoulders.

From Figure 1 it can be seen that allowing roof collapse to 28.7 inches above the H-point would not interfere with the depressed head height of 95% of the population. In a Mustang 2+2 this would allow 4 inches of vertical roof crush. To clear 99% of the population the allowable crush would be reduced by 0.6 inches.

D. Roof Strength Tests

Rollover accidents involve very complex vehicle kinematics. Cars can roll about longitudinal and transverse axes while spinning about a vertical axis. The vehicle roof may strike a fixed object, the ground, another vehicle or nothing at all. There just is no such thing as a "typical" rollover accident. For this reason, it is difficult to specify a test which will simulate a typical rollover accident.

There is at present no government specification pertaining to roof strength or methods for testing it. The SAE Recommended Practice contains specifications for three different roof tests (J857); a hill roll, a ramp roll and broadslide rollover. Ford has used two additional roof tests; a drop test and a ramp rollover employing a curved tracking rail. Recently, Ford and GM have used a static roof crush test.

All of the rollover tests have serious deficiencies. The broadslide test seldom results in rollover and the curved rail ramp roll seldom results in roof damage; the hill roll is cumbersome and probably not severe enough; the SAE ramp roll is time consuming and the vehicle often misses the ramp. In all the rollover tests the roof is loaded by the weight of the vehicle and in all but the hill roll, the vehicle is towed at 50 mph prior to rollover. The test vehicle must be a complete car with running gear intact.

The roof drop test can use partial or damaged vehicles as test items. But like the rollover tests, this test does not yield roof strength data. The roof deformation is measured but the forces producing that deformation are not. Furthermore, there is considerable variability in the results (Reference 6).

The static roof crush test does not attempt to simulate rollover accidents but does test roof strength. This test yields both the load applied to the roof and the resulting roof deformation. The test item can be a body-in-white or a complete vehicle. The roof crush test is superior to the other roof tests for measuring improvements in roof structure. Some results from roof crush tests are shown in Figure 2. In these tests, the load was applied by a hydraulic ram at the upper left corner of the windshield. The direction of the load was 25° from the vertical in a front view of the vehicle and tilted 5° forward. The roof deformation was measured in the direction of the applied load.

EAA-0281

E. Roof Forces

In many rollover accidents, the vehicle comes to rest on its roof. This fact provides a starting point in developing a roof strength standard: roof structure must support the weight of the vehicle. If we now assume that the vehicle is suspended with the roof just touching the ground and suddenly released, the load factor is, conservatively, two or twice the weight of the vehicle. In some cases the vehicle is several feet in the air prior to impacting the roof but these cases, like the 60 mph head-on collision, are so severe that the basic design of the vehicle would have to be altered to withstand the impact. It is felt that a loading of twice the weight of the vehicle:

1. is frequently experienced by vehicles in rollover accidents
2. is attainable as a minimum roof strength without altering basic roof design.

Existing roof strength is in the range of .5 to 1.5 times the weight of the vehicle (Figure 2).

J. R. Weaver

J. R. Weaver
Safety Engineering

bf
Attach.

EAA-0282

APPENDIX F

THE BIPARTISAN MCCAIN-HOLLINGS VEHICLE SAFETY PROVISIONS IN S.1072, THE SAFE, ACCOUNTABLE, FLEXIBLE, AND EFFICIENT TRANSPORTATION EQUITY ACT OF 2003 (SAFETEA), WILL PREVENT THOUSANDS OF NEEDLESS DEATHS ON THE HIGHWAY EACH YEAR

Vehicle crashes are the leading cause of death for Americans from 2 to 33, causing nearly 42,000 deaths and 3 million injuries each year. The numbers of Americans killed on the road remains at an unconscionable historic level. The National Highway Traffic Safety Administration (NHTSA) estimates the direct cost in worker productivity and other economic losses from vehicle crashes is $230 billion each year (in 2000 dollars), or $820 for every man, woman and child in the U.S.

The problem is only getting worse. In 2002, highway deaths reached their highest level since 1990, and an astounding 82 percent of the increase in deaths between 2001 and 2002 occurred in rollover crashes. SUVs, pickups and vans now make up 49 percent of new passenger sales and 36 percent of registered motor vehicles – a 70 percent increase between 1990 and 2000. Although NHTSA and the auto industry have known about the dangers of vehicle rollover and aggressivity for several decades, safety rules continue to lag behind these market trends.

Yet federal regulators acknowledge that the number of lives lost is far too high. Dr. Jeffrey Runge, Administrator of NHTSA, predicted last year in *Newsday* that the total dead could reach *50,000 annually* in 2008. "This is a Vietnam War every year," he said. "That's just not tolerable."

In 2000, Congress quickly passed the TREAD Act in the wake of the Ford/Firestone tragedy – but as members stated on the floor, major vehicle safety issues would have to be revisited. That bill, and NHTSA's subsequent tire recall, did not address increasing hazards from the growing popularity of SUVs. Left unattended, as they have been for more than two decades, rollover crashes and crashes involving vehicle mismatch will claim more lives each year. But SUVs need not be so dangerous for occupants and others—technologies available in numerous vehicles currently on the market support a panoply of obvious fixes to build a better, safer SUV for American families.

The bipartisan safety provisions in S.1072, sponsored by Senators John McCain (R-Ariz.) and Ernest Hollings (D-S.C.), will complete the unfinished business of TREAD. Hundreds of SUV owners who signed up for our campaign at www.betterSUV.org believe that American automakers *can* build a safer vehicle. So do the Ford/Firestone survivors, who have testified to the tragedies in their lives – dealing with the wrenching deaths of family members and ongoing pain from serious injuries. Yet millions of dangerous vehicles remain on the highway. Many of these losses need not have occurred and were readily preventable with improved safety design. It is time to make a better SUV.

SAFETEA PROVISIONS WILL SAVE LIVES BY ADDRESSING KEY VEHICLE SAFETY GAPS

Preventing Devastating Rollover Crashes

The diagnosis: Rollovers cause approximately 10,000 fatalities – a full one-third of all vehicle occupant deaths – and 21,000 serious injuries each year. These injuries include serious brain damage, quadriplegia, paraplegia, and other severe disabilities. Currently, there is no minimum standard to set a floor for rollover stability, though the federal government first considered such a standard more than 40 years ago.

The right medicine in SAFETEA:

- A rollover resistance standard that will require design improvements in the tippiest vehicles and support the use and further development of technologies to improve roll resistance and vehicle handling.

Treating the Deadly Epidemic of Roof Crush and Improving Rollover Survivability

The diagnosis: The current roof crush standard is woefully out of date – watered down prior to being issued in 1973 and adopted over automaker protest, it tests just one side of the roof and passes vehicles that with roofs that collapse and kill occupants in real crashes on the highway. NHTSA estimates 3,700 belted passengers are killed each year by collapsing roofs and a more rigorous roof-crush standard would save 1,400 people. Its estimate is likely too low: it excludes occupants who are ejected when roof crush opens ejection portals, as well as occupants killed by roof collapse before being ejected. And, although rollovers remain one of the most survivable crash types, inadequate crash protection standards or lack of safeguards make rollovers unnecessarily deadly crashes, exposing people to seat failure, safety belt failure and ejection.

The right medicine in SAFETEA:

- A roof strength dynamic test standard to prevent extensive roof collapse, which can measure injuries to people in evolving crash situations and test safety belt performance in rollovers.
- A rollover crashworthiness standard, including improved seat structure, safety belt design (with safety belt pretensioners that tighten in a rollover crash), side impact airbags and roof padding protection, all of which will dramatically increase rollover survivability.

Reducing Ejections from Vehicles through Windows and Doors

The diagnosis: Approximately 13,000 fatalities each year involve ejection: 8,000 people are ejected through windows, while 2,500 are ejected through open doors. NHTSA estimates that stronger side windows would save between 537 to 1,305 people each year and that stronger door locks and latches would prevent hundreds of deaths annually.

The right medicine in SAFETEA:

- An ejection mitigation standard using a combination of safety technologies, including advanced safety window glazing, side window curtain airbags and side impact airbags.
- An upgraded door lock and retention standard to reduce door openings in rollovers and other crashes and prevent ejection.
- These protections work in combination with other S.1978 standards: stronger roofs, rollover-pretensioned belts and improved belt-usage systems and reminders.

Addressing Vehicle Mismatch to Level the Playing Field

The diagnosis: Studies of real-world crashes by NHTSA show that crashes between passenger cars and light trucks are taking a record toll in lives. Automakers have promised to address the issue three times: once in 1998, again in 2000, and most recently in a well-publicized but vague voluntary program in 2003. Yet the destruction caused to passenger cars struck by SUVs requires a public and certain cure. Voluntary campaigns provide little accountability should manufacturers renege, as they did in 1998 and 2000, or fail to comply due to economic fluctuations. Moreover, consumers deserve information that allows them to make ethical choices when buying a vehicle.

The right medicine in SAFETEA:

- A vehicle compatibility and aggressivity reduction standard addressing bumper height, weight and other compatibility characteristics.
- A consumer information program to rate vehicles according to aggressivity and compatibility in multiple-vehicle collisions.
- An upgrade of the side and frontal impact standards to ensure that vehicle design also protects occupants who are inside both the struck and striking vehicle.

Fixing the Needlessly Deadly 15-Passenger Van

The diagnosis: Between 1990 and 2000, 864 occupants of 15-passenger vans died in crashes. Fatal single-vehicle crashes involving 15-passenger vans are 19 percent more likely to have included a rollover than crashes involving a car. The vans fall outside of the scope of many federal motor vehicle safety standards, such as roof crush, head restraints, braking systems and rollover warning labels. These vans also are not tested by the New Car Assessment Program (NCAP), so consumers have no idea of their crash or rollover ratings. Many innocent passengers have no idea that these vehicles are deadly, particularly when carrying more than 5 occupants.

The right medicine: A **SAFETEA** provision sponsored by Sen. Olympia Snowe (R.-Maine) would include 15-passenger vans in all relevant safety standards for occupant protection and vehicle crash avoidance, in NHTSA's dynamic rollover testing program, in NHTSA's NCAP program, and, for those vans used in commercial purposes, in all relevant truck safety standards and regulations.

Other Key Measures

Increasing Safety Belt Use: NHTSA estimates that 12,144 lives were saved by safety belts alone in 2001, and wearing a safety belt reduces a person's risk of dying in a crash by 50 percent. Current law prohibits a regulation for an audible reminder longer than 8 seconds, though Ford and other companies have tested superior reminders. The safety provisions in **SAFETEA** would allow new and innovative safety belt reminder systems that will increase belt usage.

Saving Children Killed by Vehicle Backover: According to news reports, 58 children were killed by being accidentally backed over, usually by family members, in 2002 and at least 72 were killed in 2003. There is no reason for these tragedies which devastate families.
SAFETEA would mandate a backover avoidance study and assess technologies that let drivers know when a child is behind the vehicle. The bill also suggests that NHTSA collect basic data on the number and types of non-traffic vehicular deaths and injuries.

Saving the Forgotten Child with Child Restraints: The greatest risk to child passengers ages 4- to 8-years old is the lack of restraint use in a motor vehicle. These children, as well as younger children, should be protected by booster seats to prevent serious spinal and other injuries.
SAFETEA would establish a state-based grant incentive program for booster seats.